Oregon Environmental Public Health Tracking (EPHT)

Public Drinking Water Quality (2002–2007)
Nationally Consistent Data and Measures

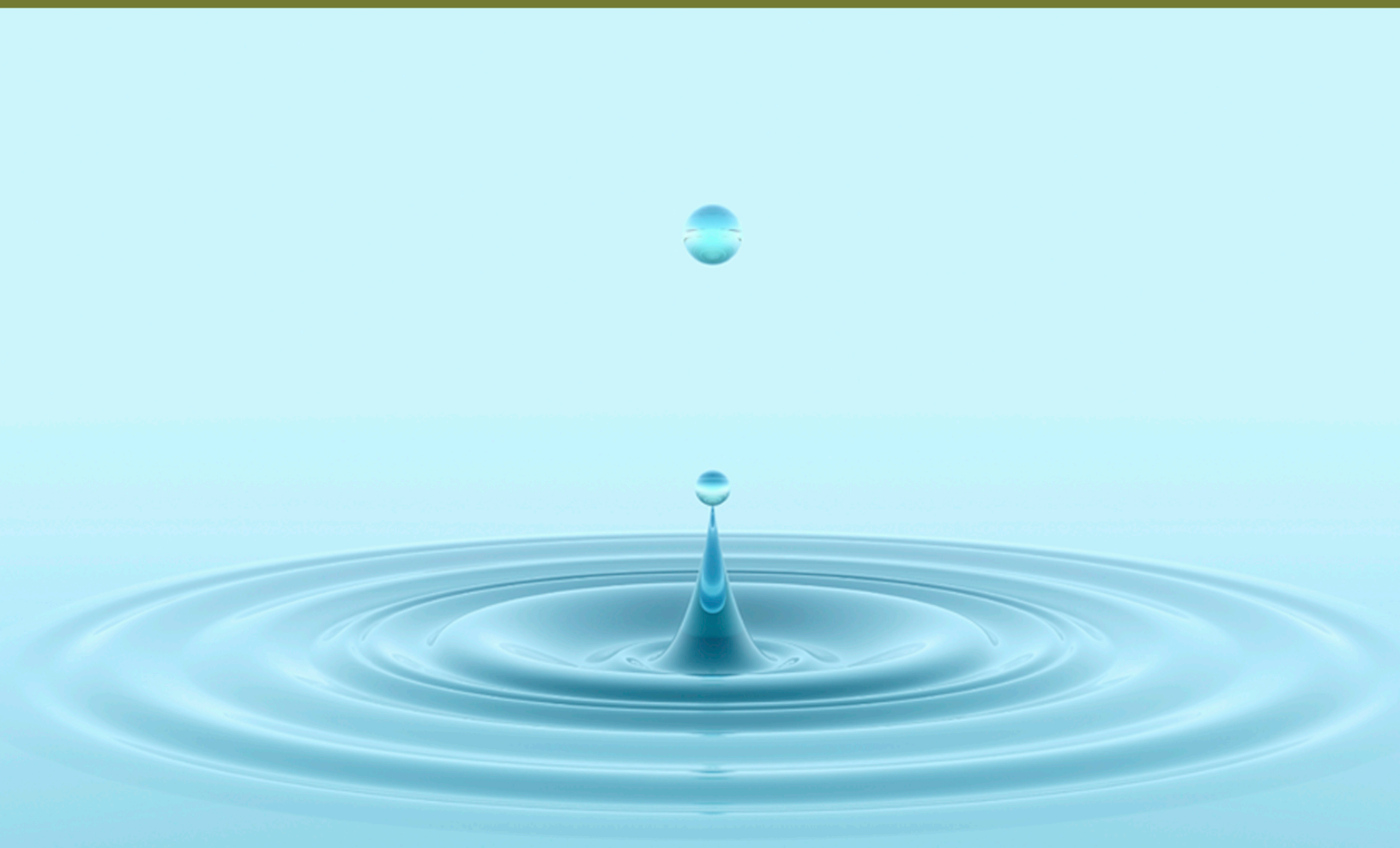


Table of Contents

Introduction to EPHT

Environmental Public Health Tracking (EPHT) is the ongoing collection, integration, analysis, interpretation and dissemination of data from environmental hazard monitoring, human exposure and health effects surveillance.

The Centers for Disease Control and Prevention (CDC) funded the Environmental Public Health Tracking Program with the following goals:

- Build a sustainable national environmental public health tracking network.
- Enhance environmental public health tracking work force and infrastructure.
- Disseminate information to guide policy and improve public health.
- Foster collaboration among health and environmental programs.

EPHT is a Web-based network of standardized electronic health and environmental data. Oregon is one of 17 grantees funded by the CDC in 2006 to participate in a collaborative development process and implement state/city networks that are components of the national network.

EPHT nationally consistent data and measures (NCDM)

As part of the implementation process, content work groups (CWG) were established to identify and recommend core measures to include in the network, examine availability of existing data, identify approaches to obtaining needed data, and develop standards and guidelines to facilitate collection of nationally consistent data.

The network content is conceptually divided into hazards, exposures and health outcomes. The CWG structure included a steering group made up of the principal investigators for grantee health departments and academic partners. The steering group was advised by content-specific teams.

Teams included content experts from the following: grantee states, cities and academic partners; CDC; other government agencies including the U.S. Environmental Protection Agency, the U.S. Geological Survey and the National Institutes of Health; and non-governmental organizations including the American Association of Poison Control Centers, the National Birth Defects Prevention Network, the National Association of Health Data Organizations, the National Association for Public Health Statistics and Information Systems and the North American Association of Central Cancer Registries.

Each content team provided recommendations for indicators and measures as well as for data sets and methods to create the recommended measures. Content groups focused on developing measures specific to an area and, in doing so, they considered potential linkages to other areas.

Rationale for tracking public drinking water quality

On average, each person consumes more than a quart of water each day. As a result, drinking water is a potentially significant route of exposure to potentially hazardous substances. The presence of contaminants in water can lead to adverse health effects, including gastrointestinal illness, reproductive problems and neurological disorders.

Previous indicator initiatives have focused on public water system compliance at the national level, but few have examined using state-specific contaminant data to track trends and to integrate environmental information with health effect data for potential relationships between drinking water quality and human health.

Measures addressing environmental public health priorities help practitioners improve decisions that protect public health. A key characteristic of EPHT is the emphasis on data integration across health, human exposure and hazard information systems. EPHT surveillance goals aim to:

- Improve the availability of drinking water quality data for identifying emerging issues and/or assessing public health effects.
- Identify priority drinking water quality issues and contaminants that should be tracked by a national EPHT program.
- Develop surveillance measures that are consistent with national Healthy People 2010 and U.S. Environmental Protection Agency (EPA) drinking water goals (i.e., EPA strategic plan) where feasible.
- Identify current gaps in data and develop recommendations for improvements to data collection, accessibility and analytical tools to address these gaps.

Overview: Public drinking water indicators and measures

Previous indicators generally have focused on regulatory compliance, but few have addressed the potential for exposure to specific drinking water contaminants. Different contaminants have different sources, different methods for regulation, and different potential for causing adverse health effects at differing concentration levels. Therefore, EPHT chose to develop measures that specifically address the unique characteristics of each contaminant and/or contaminant class.

The primary factors considered were the epidemiologic and toxicological evidence supporting an environmental exposure/health link; the uniformity of data collection within states and across the country; and the uniqueness of the contaminants' chemical and physical properties. Considering all the factors, it was determined that valid and reliable measures could be generated for disinfection byproducts (DBPs), arsenic and nitrate in community water systems (CWS).

EPHT drinking water quality measures include the levels of disinfection byproducts (DBPs), arsenic and nitrate in finished drinking water and the potential population exposed to these contaminants. Each of these measures captures some aspect of a hazard, exposure or an intervention effort.

Calculation of these measures includes data collected as early as 2002, the first year during which representative data were collected for all of the contaminants of interest. Data were provided through the Safe Drinking Water Information System (SDWIS) of the Oregon Department of Human Services Drinking Water Program. Community water systems represent non-transient public water systems that serve at least 15 connections or provide year-round service for at least 25 people.

Public drinking water measures

The range of populations served by community water systems as the primary drinking water source in homes varies from 95 percent to as low as 40 percent within different states. In Oregon, 3,151,979 of 3,583,027 residents (approximately 88 percent of the population) obtain their primary drinking water from a community water system. This is very close to the national average of 89 percent.

A. Arsenic

Arsenic is a naturally occurring element widely distributed in soil and minerals. Arsenic cannot be destroyed; it can only change its form. In the natural environment, arsenic combines with oxygen, chlorine and sulfur to form inorganic arsenic compounds. Inorganic arsenic naturally occurs in the earth's crust and soil in a wide range of concentrations. It may enter water from runoff and leaching; and enter air, water and land from wind-blown dust. Many common arsenic compounds can dissolve in water. Most of the arsenic in water will ultimately end up in soil or sediment.

Inorganic arsenic compounds are used as preservatives, mainly in wood. Copper chromated arsenate is used to make pressure-treated lumber. Although it is no longer used in the United States for residential applications, it is still used in industrial applications. Arsenic absorbed or ingested by animals and plants combines with carbon and hydrogen to form organic arsenic compounds. Organic arsenic compounds are used as pesticides, primarily on cotton fields and in orchards.

Arsenic has been identified as a human carcinogen by the International Agency for Research on Cancer. Exposure to arsenic at a concentration of hundreds of micrograms per liter (mcg/L) in the drinking water of Taiwan, Chile, Argentina, Mexico, Bangladesh and India has been associated with adverse health effects including lung, bladder, liver and skin cancers. Other adverse health effects include nausea, cardiovascular disease, developmental and reproductive effects, diabetes, and skin keratosis and hyperpigmentation.

In 2006 the U.S. Environmental Protection Agency (EPA) strengthened the regulatory drinking water standard on the basis of bladder and lung cancer risks and reduced the maximum contaminant level (MCL) of arsenic allowed in drinking water from 50 mcg/L to 10 mcg/L. The EPA also has set limits on the amount of arsenic that industrial sources can release into the environment and has restricted or stopped many of the uses of arsenic in pesticides.

There are tests available to measure arsenic in blood, urine, hair and fingernails. The urine test is the most reliable test for arsenic exposure occurring within the last few days. Tests on hair and fingernails can measure exposure to high levels of arsenic during the past six to 12 months. These tests can determine exposure to above-average levels of arsenic. They cannot determine whether arsenic levels have adversely affected an individual's health.

Based on current understanding of the health effects of arsenic, the potential for adverse effects from drinking water exposure to arsenic in the United States is very low for most community water systems.

The arsenic measures below provide simple estimates of the number of community water supplies with high levels of arsenic that could potentially cause adverse health effects, as well as the number of people potentially exposed to water that does not meet regulatory limits for arsenic.

A.1. Annual percentage and number of community water systems (CWS) with any arsenic maximum contaminant level (MCL) violations, and annual percentage and number of people served by CWSs with any arsenic MCL violations

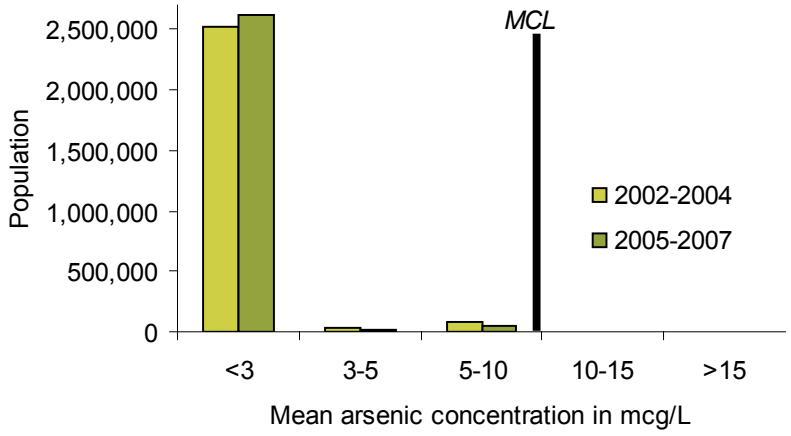
From 2002 to 2007 less than 1 percent of Oregonians who received water from community water systems were exposed to water not meeting the EPA's current arsenic drinking water standard of 10 mcg/L (see Table 1). This number has varied from 0 percent in 2003, 2004 and 2006 to 0.4 percent in 2002, without systematic increase or decrease. During 2002 to 2007 the number of CWSs with arsenic violations ranged from 0 percent in 2006 to 1.3 percent in 2007. (Using the MCL of 50 mcg/L, which was applicable from 2002–2005, there were no arsenic violations in 2004 or 2005; one occurred in 2002 and in 2003.)

Table 1. Annual percentage and number of CWSs with arsenic MCL violations, and number of people served by CWSs with arsenic MCL violations (using the current standard of 10 mcg/L)

	Annual percentage and count of CWSs with any arsenic MCL violation		Annual percentage and count of people served by CWSs with any arsenic MCL violation	
Year	Percent	*(count)*	Percent	*(count)*
2002	0.5	*(4)*	0.4	*(13,637)*
2003	0.6	*(5)*	0.0	*(760)*
2004	0.7	*(6)*	0.0	*(340)*
2005	0.5	*(4)*	0.3	*(8,049)*
2006	0.0	*(0)*	0.0	*(0)*
2007	1.3	*(11)*	0.2	*(5,877)*

A.2. Three-year compliance period mean arsenic concentrations in CWSs and number of people served by mean arsenic concentration, with cut-points ≤3, 3-5, 5-10, 10-15, >15 mcg/L

In Graph 1 and Table 2, the mean arsenic concentrations are shown in five categories (≤3, >3-5, >5-10, >10-15 and >15 mcg/L) for two three-year arsenic compliance periods. Not only are arsenic levels above the 10 mcg/L MCL rare, the water delivered to more than 95 percent of public water recipients had average arsenic levels lower than 30 percent of the current MCL, i.e., less than 3 mcg/L.



Note: The current arsenic maximum contaminant level (MCL) of 10 mcg/L is indicated as a black bar.

Graph 1. Distribution of number of people by mean arsenic concentrations for compliance periods 2002–2004 and 2005–2007

Table 2. Three-year compliance period mean arsenic concentrations across CWSs and number of people served by mean arsenic concentrations

Compliance period	mcg/L	Number of CWSs by mean arsenic concentration	People served by mean arsenic concentration	
2002-2004	≤3	580	2,520,078	
	>3-5	36	25,129	
	>5-10	58	86,122	
	>10-15	0	0	
	>15	11	1,046	
			Total	2,632,375
2005-2007	≤3	630	2,627,056	
	>3-5	28	11,494	
	>5-10	55	57,757	
	>10-15	5	1,250	
	>15	5	400	
			Total	2,697,957

Note: Only CWSs with valid measurements are included.

B. Disinfection byproducts

Public water may contain microorganisms, such as viruses and bacteria, that can cause serious illness (i.e., gastrointestinal disorders or diarrhea) and even death. Public water suppliers disinfect their water to kill these microorganisms. Disinfection byproducts (DBPs) are a family of chemicals formed when these disinfectants react with naturally occurring organic matter and other substances in source water.

Levels of disinfection byproducts depend on the nature of the source water and type of disinfection, and can change with seasons of the year, rainfall and distance from treatment plant to consumer's tap. Surface water sources, such as reservoirs and streams, are more likely to have higher disinfection byproduct levels than ground water sources.

There are several ways disinfection byproducts can enter a person's body: through drinking tap water; through breathing when using tap water because some DBPs may be released into the air (the hotter the water is, the more likely it is that DBPs will be released); and small amounts through the skin when bathing or showering.

When people are exposed to disinfection byproducts at high levels for many years, they may develop cancer or problems with their liver, kidneys or circulatory system. There also may be a connection with miscarriages, premature births, low birth weight and birth defects.

EPA requires that systems use water treatment methods that reduce formation of disinfection byproducts, and protect consumers from waterborne disease and the potential harmful effects of disinfection byproducts. EPA regulations aim to minimize potential risks from disinfection byproducts while protecting against disease-causing microorganisms.

Disinfectant byproducts include haloacetic acids (HAA) and trihalomethanes (THM). HAA5 is the sum of monochloroacetic, dichloroacetic, trichloroacetic, monobromoacetic and dibromoacetic

acids. Total THM (TTHM) is the sum of four chlorine and bromine-containing trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane, bromoform).

The maximum allowable contaminant levels are 60 mcg/L for HAA5 and 80 mcg/L for TTHM. These levels are calculated as running annual averages. A running annual average is the arithmetic average of results calculated at the end of every quarter for the previous consecutive four-quarter period. Compliance is achieved when the running annual averages are below 60 mcg/L and 80 mcg/L for HAA5 and TTHM, respectively.

TTHM and HAA5 act as indicators for a range of DBPs. There are many other known DBPs, as well as possibly as-yet unidentified DBPs, present in disinfected water. TTHM and HAA5 typically occur at higher levels than other known DBPs; their presence may, therefore, indicate the presence of other DBPs.

TTHM and HAA5 measures provide estimates of the number of community water supplies with high levels of DBPs that could potentially cause adverse health effects. They also can help estimate the number of people potentially exposed to water that does not meet regulatory limits for DPBs.

For CWSs that sampled DBPs, a missing quarter value was assigned the mean value for the calendar year or, if no data were available for the entire year, the mean of the values for the closest preceding and following years. Missing values are reported for systems that did disinfect, but for which no data were available. Concentration values of "0" and "no violation" are reported for CWSs that did not disinfect.

B.1. Percentage and number of CWSs with disinfection byproduct (DBP) MCL violations; percentage and number of people served by CWSs with MCL violations (HAA5, TTHM)

In Table 3, disinfection byproduct violations are shown by community water system and by population served. From 2002 to 2007 between 0.6 percent and 2.1 percent of community water systems had at least one violation of either the HAA5 or the TTHM standard, and between 0.2 percent and 3.5 percent of the population may have received water with DBP levels above either the HAA5 or TTHM MCL during the year.

Table 3. Annual number and percentage of CWSs with a DBP violation, and number and percentage of people receiving water from a CWS with a DBP violation

	Community water systems		Population served	
Year	Percent	*(count)*	Percent	*(count)*
2002	0.6	*(5)*	0.2	*(7,396)*
2003	0.7	*(6)*	3.5	*(108,949)*
2004	1.7	*(15)*	1.0	*(30,139)*
2005	2.1	*(18)*	1.2	*(37,647)*
2006	0.6	*(5)*	0.3	*(10,458)*
2007	0.6	*(5)*	0.3	*(10,722)*

When examined by quarter (see Table 4), the percentages of DBP violations further decrease. Violations occurred in more than 1 percent of the community water systems in only one quarter of the six years (1.4 percent in the third quarter of 2005). Violations occurred in less than 1 percent of the systems in all but three quarters. The population served by community water systems with a DBP violation exceeded 1 percent in only one quarter (3.1 percent in the first quarter of 2003).

This indicates less than 0.5 percent of CWSs (supplying less than 0.5 percent of the population) violated DBP drinking water standards for extended periods.

Table 4. Quarterly percentage and number of CWSs and percentage and number of people receiving water from a CWS with a DBP violation

		Water systems		Population	
Year	Quarter	Percent	*(count)*	Percent	*(count)*
2002	1	0.0	*(0)*	0.0	*(0)*
	2	0.0	*(0)*	0.0	*(0)*
	3	0.5	*(4)*	0.2	*(4,945)*
	4	0.1	*(1)*	0.1	*(2,451)*
2003	1	0.2	*(2)*	3.1	*(97,863)*
	2	0.0	*(0)*	0.0	*(0)*
	3	0.3	*(3)*	0.2	*(7,626)*
	4	0.1	*(1)*	0.1	*(3,460)*
2004	1	0.2	*(2)*	0.3	*(10,363)*
	2	0.0	*(0)*	0.0	*(0)*
	3	1.0	*(9)*	0.5	*(16,840)*
	4	1.0	*(9)*	0.4	*(13,741)*
2005	1	0.5	*(4)*	0.1	*(3,005)*
	2	0.8	*(7)*	0.5	*(16,150)*
	3	1.4	*(12)*	0.8	*(23,797)*
	4	0.7	*(6)*	0.2	*(6,575)*
2006	1	0.1	*(1)*	0.3	*(9,813)*
	2	0.2	*(2)*	0.3	*(10,013)*
	3	0.3	*(3)*	0.0	*(445)*
	4	0.1	*(1)*	0.0	*(195)*
2007	1	0.0	*(0)*	0.0	*(0)*
	2	0.2	*(2)*	0.3	*(10,013)*
	3	0.5	*(4)*	0.3	*(10,647)*
	4	0.2	*(2)*	0.0	*(275)*

Given four quarters per year and two DBP standards (for TTHM and HAA5), there could be up to eight violations per year in a community water system. The number of violations, by system and by population served, is shown in Table 5. No system had more than four violations per year and more than 95 percent of the systems had no violations in any of the years.

Most systems violating a DBP standard in a given year did so only once. The proportion of population served receiving water from community water systems with more than one violation was consistently below 0.5 percent. Between 2002 and 2007 the percentage served by systems with no DBP violations ranged from 96.3 percent in 2003 to 99.6 percent in 2002.

Table 5. Number and percentage of CWSs and number and percentage of people receiving water from a CWS with different numbers of DBP violations, by year

		Water systems		Population	
Year	Violations	Percent	*(count)*	Percent	*(count)*
2002	0	97.3	*(840)*	99.6	*(3,138,080)*
	1	0.6	*(5)*	0.2	*(7,396)*
	2	0.0	*(0)*	0.0	*(0)*
	3	0.0	*(0)*	0.0	*(0)*
	4	0.0	*(0)*	0.0	*(0)*
	5-8	0.0	*(0)*	0.0	*(0)*
2003	0	97.2	*(839)*	96.3	*(3,036,527)*
	1	0.7	*(6)*	3.5	*(108,949)*
	2	0.0	*(0)*	0.0	*(0)*
	3	0.0	*(0)*	0.0	*(0)*
	4	0.0	*(0)*	0.0	*(0)*
	5-8	0.0	*(0)*	0.0	*(0)*
2004	0	96.2	*(830)*	98.8	*(3,115,337)*
	1	1.3	*(11)*	0.6	*(19,884)*
	2	0.1	*(1)*	0.0	*(425)*
	3	0.2	*(2)*	0.3	*(9,630)*
	4	0.1	*(1)*	0.0	*(200)*
	5-8	0.0	*(0)*	0.0	*(0)*
2005	0	95.8	*(827)*	98.6	*(3,107,829)*
	1	1.0	*(9)*	0.6	*(18,597)*
	2	0.6	*(5)*	0.5	*(15,305)*
	3	0.2	*(2)*	0.0	*(1,440)*
	4	0.2	*(2)*	0.1	*(2,305)*
	5-8	0.0	*(0)*	0.0	*(0)*
2006	0	97.3	*(840)*	99.5	*(3,135,018)*
	1	0.2	*(2)*	0.0	*(250)*
	2	0.3	*(3)*	0.3	*(10,208)*
	3	0.0	*(0)*	0.0	*(0)*
	4	0.0	*(0)*	0.0	*(0)*
	5-8	0.0	*(0)*	0.0	*(0)*
2007	0	97.3	*(840)*	99.5	*(3,134,754)*
	1	0.3	*(3)*	0.0	*(709)*
	2	0.1	*(1)*	0.3	*(9,813)*
	3	0.1	*(1)*	0.0	*(200)*
	4	0.0	*(0)*	0.0	*(0)*
	5-8	0.0	*(0)*	0.0	(0)

Note: Maximum number of violations is eight, corresponding to violations of both TTHM and HAA5 standards in all four quarters.

Adding up the number of months of water received from community water systems for all Oregon residents provides the number of person-months. This is an estimate of the potential population exposure to water contaminants in the CWSs.

Table 6 shows that from 2002 to 2007 between 98.9 percent and 99.7 percent of person-months were free of DBP violations, i.e., the possible population exposure to water with DBP levels exceeding the MCL was consistently below 1.1 percent of the potential population exposure.

Table 6. Percentage of person-months with no DBP violation, by year

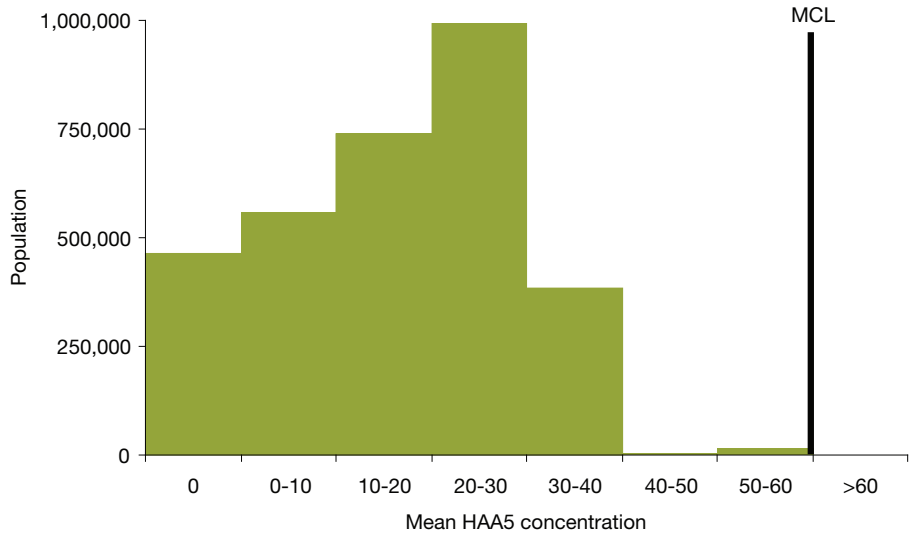
Year	Percent person-months
2002	99.7
2003	98.9
2004	99.5
2005	99.4
2006	99.6
2007	99.6

Note: The number of person-months without DBP violations is the sum of the CWS populations multiplied by the number of months in which no DBP violation occurred.

B.2. Annual percentage and number of people served by CWS by mean DBP concentration and maximum concentration greater than specific reference levels of 50th, 75th, 90th and 95th percentiles of the distribution of mean DBP levels in reference year 2005

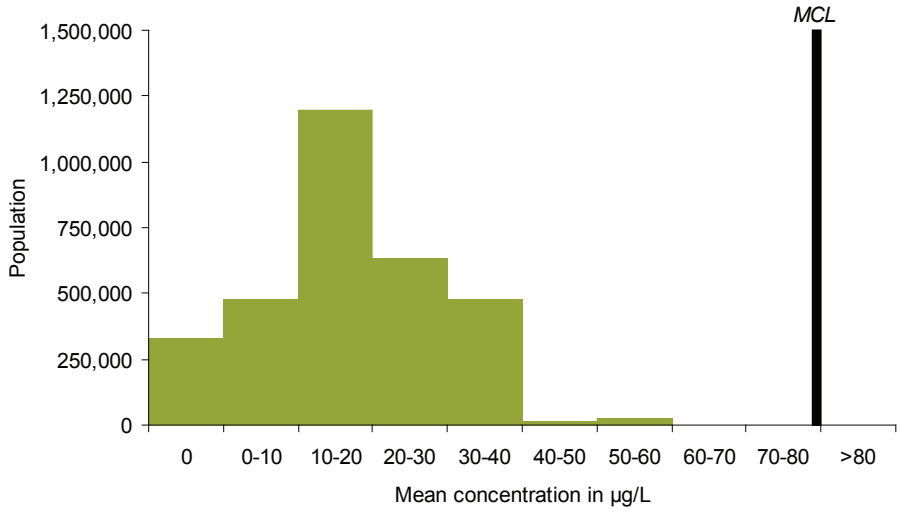
The following graphs and tables present the number and percentage of people who received water with different levels of HAA5 and TTHM concentration.

Between 2002 and 2007 more than 99.5 percent of water consumers of CWS received water with mean HAA5 and TTHM that did not exceed the MCL. For more than 80 percent of consumers, the average DBP levels were less than half the MCL. Graph 2. shows the distribution of HAA5 mean concentrations relative to the MCL for 2007. Graph 3 shows the 2007 distribution for TTHM.



Note: The Maximum Contaminant Level (MCL) of 60 mcg/L is indicated as a black bar.

Graph 2. Distribution of number of people by mean HAA5 concentrations for 2007



Note: The maximum contaminant level (MCL) of 80 mcg/L is indicated as a black bar.

Graph 3. Distribution of number of people by mean TTHM concentrations for 2007

Graph 4a (HAA5) and Graph 4b (TTHM) show how many people received water from community water systems with maximum HAA5 and TTHM levels in five reference level categories. The reference levels are based on the 50th, 75th, 90th and 95th percentile of average HAA5 and TTHM levels in 2005 (i.e., the highest mean concentration levels to which 50, 75, 90 and 95 percent of the population were possibly exposed in 2005). The reference levels were 26.3, 27.9, 36.3 and 37.5 mcg/L for HAA5; and 24.3, 31.3, 37.5 and 45.0 mcg/L for TTHM.

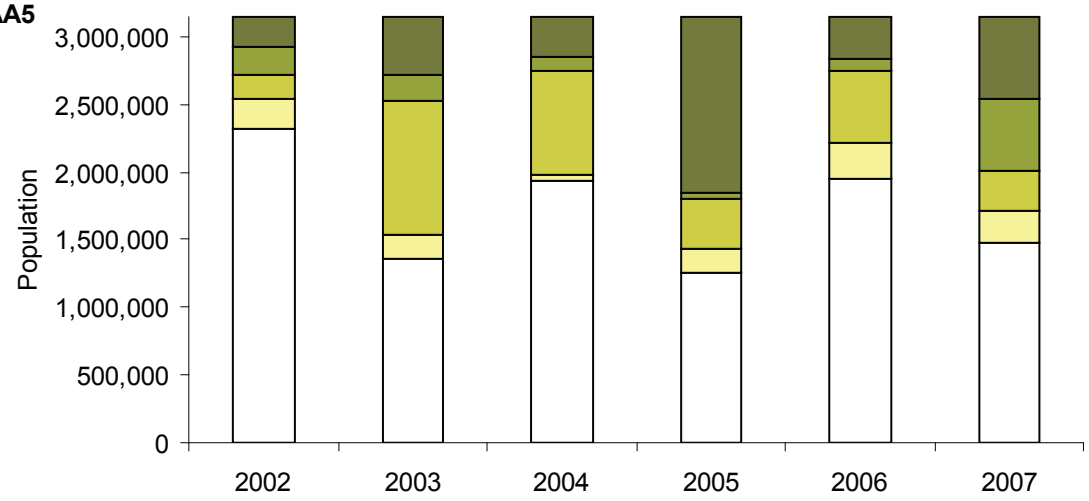
The data presented in Graph 4a and Graph 4b show significant variations from year to year and between HAA5 and TTHM. For example, in 2005 a larger proportion of the population received water with maximum DBP concentrations in the highest reference level categories. In that year 41.3 percent of population served received water with maximum HAA5 concentrations above the 95th percentile, more than twice the percentage of population served in 2007 (19 percent) and more than three times the percentage of population served in any other year.

A similar pattern was observed in TTHM concentrations. In 2005, 20.8 percent of population served received water with maximum TTHM concentrations above the 95th percentile, approximately twice the percentage of population served in 2007 (10.5 percent) and more than three times the percentage of population served in any other year.

The percentage of population receiving water with HAA5 concentrations in the highest reference level was approximately twice the percentage receiving water with TTHM concentrations in the highest reference level, e.g., 41.3 percent versus 20.8 percent in 2005. There is no clear trend for a decrease or increase in population proportions between reference levels or within specific reference level categories for either HAA5 or TTHM.

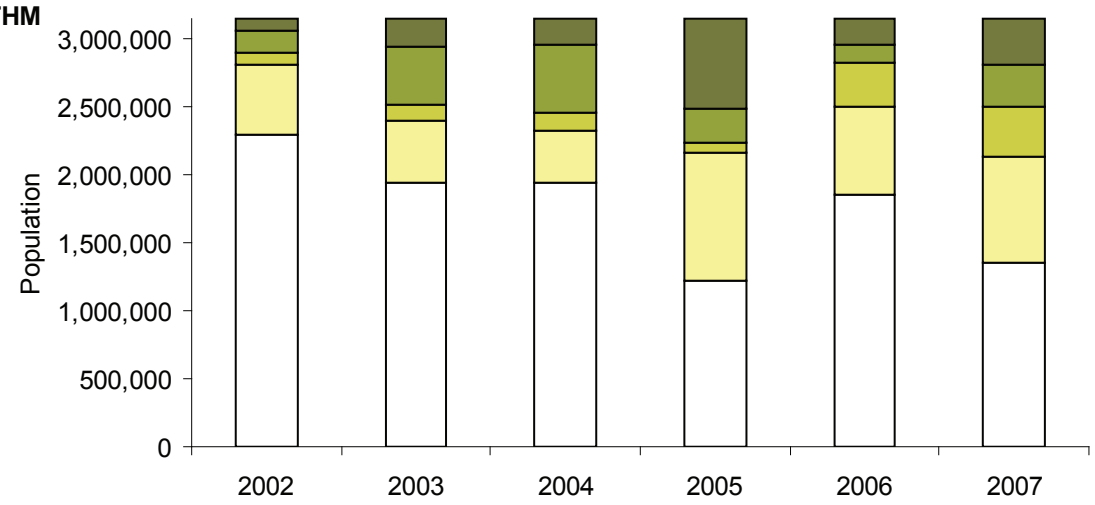
It is important to note that limits for even the highest reference level category (the 95th percentile) are 37.5 and 45.0 for HAA5 and TTHM, respectively. These levels are still far below the maximum contaminant levels of 60 mcg/L for HAA5 and 80 mcg/L for TTHM.

HAA5



Percentile	2002	2003	2004	2005	2006	2007
95–100	7.1%	13.4%	9.4%	41.3%	9.7%	19.0%
90–95	6.5%	6.1%	3.2%	1.4%	2.8%	17.1%
75–90	5.4%	31.5%	24.4%	11.6%	17.1%	9.2%
50–75	7.3%	5.5%	1.3%	5.5%	8.5%	7.4%
<50	73.5%	43.3%	61.5%	39.9%	61.7%	47.1%

TTHM



Percentile	2002	2003	2004	2005	2006	2007
95-100	2.6%	6.3%	5.9%	20.8%	6.2%	10.5%
90-95	5.1%	13.7%	16.2%	8.2%	4.2%	9.9%
75-90	2.8%	3.6%	3.8%	2.1%	10.1%	11.6%
50-75	16.3%	14.3%	12.3%	29.7%	20.7%	24.9%
<50	73.0%	61.8%	61.6%	38.9%	58.6%	42.9%

Note: The reference levels are population-weighted percentiles of the 2005 mean levels. The 50th, 75th, 90th and 95th percentiles are 26.3, 27.9, 36.3 and 37.5 mcg/L for HAA5; and 24.3, 31.3, 37.5 and 45.0 mcg/L, for TTHM. Maximum contaminant levels (MCL) are 60 mcg/L for HAA5 and 80 mcg/L for TTHM.

Graph 4a and Graph 4b. Number and percentage of people receiving water from CWS with maximum DBP (HAA5 and TTHM) levels in five reference level categories.

C. Nitrate

Nitrate is the most common contaminant in ground water aquifers worldwide. Nitrate is composed of nitrogren-oxygen chemical units that combine with various organic and inorganic compounds.

Nitrate (NO_3) originates in drinking water from nitrate-containing fertilizers, sewage/septic tanks and decaying natural material, such as animal waste. As a result of human activities and population growth, nitrate is increasing in water resources. The greatest use of nitrate is as fertilizer.

Nitrate does not evaporate, is very soluble in water and can easily migrate. Since nitrate is very soluble and does not bind to soils, nitrate has a high potential to migrate to ground water. Because these compunds do not evaporate, nitrate and nitrite are likely to remain in water until consumed by plants or other organisms.

Nitrate was first identified as a public health threat in drinking water in 1945 when high nitrate levels from private wells were shown to cause methemoglobimia or "blue baby syndrome" in infants who received formula mixed with well water. When an infant is exposed to nitrate, the chemical can be converted to nitrite in the body, which oxidizes ferrous iron in blood to form methemoglobin-containing ferric iron.

Methemoglobin cannot transfer oxygen to tissues; thus an excess of nitrate or nitrite can starve the body of oxygen and produce a clinical condition known as methemoglobinemia, which manifests as cyanosis, a condition in which the lips and extremities turn dusky gray or blue. Infants younger than 4 months old are more sensitive than adults, and can develop "blue baby" syndrome from intake of nitrate higher than 10 mg/L. Blue baby syndrome is fatal in about 10 percent of cases (ATSDR, 2007).

Long-term exposure to high nitrate levels in drinking water has been found in some studies to be a risk factor for several types of cancer (such as gastric, colorectal, bladder, urothelial, brain, esophageal and ovarian cancer, and non-Hodgkin's lymphoma). However, other studies have found no association.

There also is some evidence to suggest that exposure to nitrate in drinking water is associated with adverse reproductive outcomes such as spontaneous abortion (miscarriage), intrauterine growth restriction, and various birth defects. However, other studies have found no association.

Nitrate regulations became effective in 1992. If nitrate levels consistently exceed the maximum contaminant level (MCL), the community water system must notify the public via newspapers, radio, TV and other means.

Additional actions, such as providing alternative drinking water supplies, may be required to prevent risks to public health. These measures (of community water systems and population served who are potentially exposed to water not meeting MCLs for nitrate) provide simple estimates of the potential for adverse health effects.

C.1. Annual percentage and number of CWSs with any nitrate MCL violation; annual percentage and number of people served by CWSs with any nitrate MCL violation

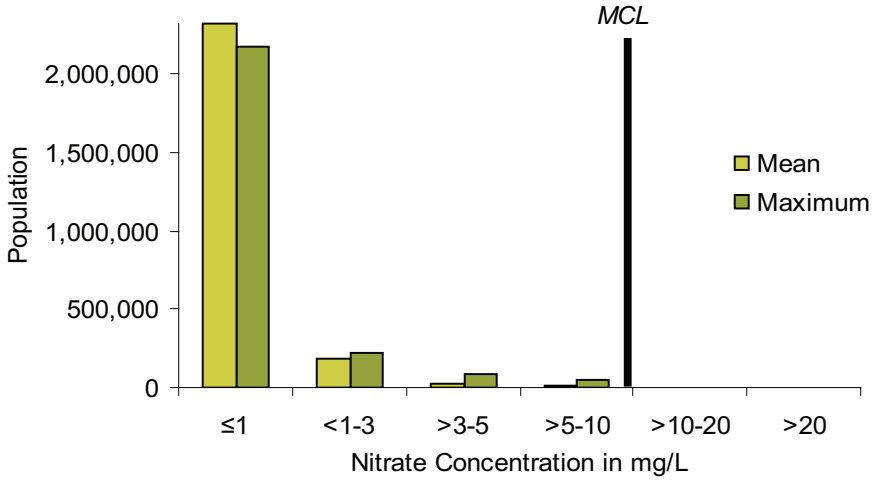
Table 7 presents the proportion of CWSs with any nitrate violations and the proportion of people receiving water from CWSs in which a nitrate violation occurred. Both were consistently below 0.5 percent in every year between 2002 and 2007.

Table 7. Annual percentage and number of CWS with any nitrate MCL violations, and number of people served by CWS with any nitrate MCL violations

	Annual percentage and count of CWSs with any nitrate MCL violation		Annual percentage and count of people served by CWSs with any nitrate MCL violation	
Year	Percent	*(count)*	Percent	*(count)*
2002	0.2	*(2)*	0.2	*(6,447)*
2003	0.5	*(4)*	0.1	*(3,686)*
2004	0.4	*(3)*	0.3	*(10,201)*
2005	0.4	*(3)*	0.1	*(2,176)*
2006	0.2	*(2)*	0.1	*(1,800)*
2007	0.2	*(2)*	0.1	*(1,800)*

C.2. Annual mean and maximum nitrate concentration in CWS, and percentage and number of people served by CWS by mean and maximum nitrate concentration, with cut-points ≤1, 1-3, 3-5, 5-10, 10-20, >20 mg/L

More than 90 percent of the population received drinking water with average nitrate levels lower than 1 mg/L, i.e., 10 percent of the MCL, and maximum yearly nitrate levels under 3 mg/L or 30 percent of the MCL. This is illustrated in Graph 5 for 2007.



Note: Nitrate maximum contaminant level (MCL) of 10 mg/L is indicated as a black bar.

Graph 5. 2007 mean and maximum nitrate concentrations across CWS

Table 8 shows the community water systems and people served by mean and maximum nitrate levels in six concentration categories. The percentage of CWS with maximum yearly nitrate levels that exceeded the MCL of 10 mg/L was below 0.6 percent in all years. The percentage of systems with an average nitrate concentration exceeding the MCL was less than 0.3 percent in all years.

The percentage of people served where maximum yearly nitrate levels exceeded the MCL of 10 mg/L was below 0.4 percent in all years. The range was from 0.07 percent in 2006 and 2007

to 3.9 percent in 2004. The percentage of people served in which the yearly average nitrate concentration exceeded the MCL was less than 0.08 percent. No trends over time were evident.

Table 8. Annual mean and maximum nitrate concentrations across CWS and the number of people served, by mean and maximum nitrate concentrations

		Mean nitrate concentration		Maximum nitrate concentration	
Year	mg/L	CWS	People served	CWS	People served
2002	≤1	510	2,354,764	489	2,156,095
	<1-3	117	161,525	124	264,483
	>3-5	32	19,559	38	56,085
	>5-10	15	6,489	22	61,224
	>10-20	1	1,997	2	6,447
	>20	0	0	0	0
2003	≤1	530	2,386,012	504	1,536,293
	<1-3	128	137,321	145	912,200
	>3-5	41	54,433	38	68,329
	>5-10	19	8,334	27	65,592
	>10-20	0	0	4	3,686
	>20	0	0	0	0
2004	≤1	549	2,372,456	517	1,698,314
	<1-3	141	172,309	162	782,091
	>3-5	35	62,540	31	69,359
	>5-10	22	13,836	34	61,176
	>10-20	0	0	3	10,201
	>20	0	0	0	0
2005	≤1	543	2,429,350	520	2,227,140
	<1-3	140	161,932	153	294,389
	>3-5	36	49,192	36	69,989
	>5-10	19	3,978	27	51,058
	>10-20	1	300	3	2,176
	>20	0	0	0	0
2006	≤1	529	2,436,029	506	2,250,128
	<1-3	137	158,212	148	280,403
	>3-5	38	36,386	34	34,840
	>5-10	11	6,661	27	71,917
	>10-20	2	1,800	2	1,800
	>20	0	0	0	0
2007	≤1	527	2,315,747	506	2,169,304
	<1-3	132	186,529	140	225,340
	>3-5	41	19,018	45	83,665
	>5-10	13	6,401	21	47,646
	>10-20	1	60	2	1,800
	>20	0	0	0	0

Major limitations

Violations of the maximum contaminant level (MCL) are not always explained by contaminants in the water. There may be data entry or data translation errors in a database. Sometimes the frequency of testing in a water system can play a role. In addition, different water systems may have different testing frequencies throughout the year. Where the water sample was taken can also affect data. For some contaminants (e.g., DBPs) and/or systems with more than one point in the distribution system where water is supplied, water quality may vary among different parts of the distribution system.

Sampling may be too infrequent to capture high levels or, for some contaminants, capture short-term variability. Differences in frequency of sampling between CWS for a specific contaminant limit comparisons between systems and between counties. Estimates of the number of people served by a community water system may be inaccurate and of variable quality when based on estimates conducted by the water supplier. Human behaviors (e.g., showering and bathing time, consumption of tap water, use of bottled water, and exposure to water at workplaces or other locations outside the home) greatly influence exposure, complicating efforts to estimate exposure from tap water measurements.

Limited information on the spatial extent of community water systems impedes comprehensive tracking of drinking water contaminants and health effects; prevents the development of linked indicators; and limits the accuracy and validity of measures of population exposed to drinking water contaminants. More accurate methods of estimating population served by community water systems need to be developed along with identification of geographical water system service boundaries to allow studies of the potential risk for adverse health effects.

Index to tables and graphs

A. Arsenic

B. Disinfection byproducts

C. Nitrate

Glossary

Assessment	One of the three core functions of public health (assessment, policy development, assurance). Comprises monitoring health status to identify community health problems; diagnosing and investigating health problems and health hazards in the community; and evaluating the effectiveness, accessibility and quality of population-based health services.
ATSDR	Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services (DHHS)
CDC	Centers for Disease Control and Prevention, U.S. DHHS
Community water system (CWS)	A public water system that serves year-round residents of a community, subdivision or mobile home park with at least 15 service connections or an average of at least 25 residents.
Compliance	The act of meeting all state and federal drinking water regulations.
Contaminant	Anything found in water (including microorganisms, minerals, chemicals, etc.) that may be harmful to human health.
Contaminant, inorganic	Mineral-based compounds such as metals, nitrate and asbestos. These contaminants are naturally occurring in some water, but also can enter water as a result of farming, chemical manufacturing and other human activities. EPA has set legal limits on 15 inorganic contaminants.

Contaminant, organic	Carbon-based chemicals, such as solvents and pesticides, that can enter water through runoff from cropland or discharge from factories.
CWS	See community water system.
DBP	See disinfection byproducts.
DHHS	U. S. Department of Health and Human Services
DHS	Oregon Department of Human Services
Disinfectant	A chemical (commonly chlorine, chloramine or ozone) or physical process (e.g., ultraviolet light) that inactivates microorganisms such as bacteria, viruses and protozoa.
Disinfection byproduct (DBP)	Disinfection byproducts form when disinfectants used to treat drinking water react with naturally occurring materials in the water (e.g., decomposing plant material). The U.S. Environmental Protection Agency (EPA) regulates two classes of DBPs: total trihalomethanes (TTHM) and five haloacetic acids (HAA5). TTHM and HAA5 can indicate the presence of many other chlorination DBPs; thus, reduction in TTHM and HAA5 generally indicates a reduction in DBPs from chlorination. DBPs in drinking water can change from day to day depending on the season; water temperature; amount of disinfectant added; the amount of plant material in the water; and other factors.
Environmental Public Health Tracking (EPHT)	The national initiative to establish a network to enable the ongoing collection, integration, analysis and interpretation of data about environmental hazards, exposure to environmental hazards and health effects.
EPHT Program	Environmental Public Health Tracking: This national program is in the Division of Environmental Hazards and Health Effects of CDC's National Center for Environmental Health; Oregon's program is in the Toxicology, Assessment and Tracking Section of the Oregon DHS Office of Environmental Public Health.
Exposure	Proximity to and/or contact with a substance having the potential to cause disease in such a manner that effective transmission of the agent or harmful effects of the agent may occur.

Finished water	Treated water that is ready for delivery to consumers.
Gram	A metric unit of mass equal to one thousandth of a kilogram. There are 28 grams in 1 ounce.
Ground water	Water that systems pump and treat from aquifers (natural reservoirs below the earth's surface).
HAA5	Five regulated haloacetic acids (monochloro-, dichloro-, trichloro-, monobromo-, dibromo-). This is a widely occurring class of DBPs formed during disinfection with chlorine and chloramine.
Hazard	A source that may adversely affect health from past, current or future exposures.
Health advisory	An EPA document that provides guidance and information on contaminants affecting human health that may occur in drinking water, but which EPA does not currently regulate.
Health effect, acute	An immediate (i.e., within hours or days) effect that may result from exposure to certain drinking water contaminants (e.g., pathogens).
Health effect, chronic	The possible result of exposure for many years to a drinking water contaminant at levels above its maximum contaminant level (MCL).
Hyperpigmentation	An increase in the natural color of the skin; darkening of the skin.
Indicator	A statistic that provides information on trends. Environmental public health indicators supply information about a population's health status with respect to environmental factors that can be used to assess health in a specified population through direct or indirect measures.
Keratosis	A localized horny overgrowth of the upper layer of skin, most commonly on the soles and palms, caused by long-term arsenic ingestion.
Kilogram	A metric unit of mass equal to 1,000 grams (2.2 pounds).
Liter	Metric system unit of volume equal to 61,022 cubic inches (1.0567 U.S. quarts wet) 1 liter = 1,000 milliliters. The abbreviation for liter is "L."

mcg/L	Micrograms per liter; a unit of measure for arsenic in water that equals one millionth of a gram of lead per liter of water.
MCL	See maximum contaminant level.
MCL violation	Failure to keep a contaminant level below its MCL.
mg/L	Milligrams per liter; a unit of measure for arsenic in water that equals one thousandth of a gram of arsenic per liter of water.
Maximum contaminant level (MCL)	The maximum permissible level of a contaminant in water that is delivered to any user of a public water system which the Safe Drinking Water Act defines as the level that may be achieved with the use of the best available technology, treatment techniques and other means that the EPA finds available, taking cost into consideration. Some states set MCLs that are stricter than the EPA's.
Measure	A standard of progress in a particular aspect of a program; a basis for comparison or a reference point against which other trends can be evaluated.
Monitoring	Testing that water systems must perform to detect and measure contaminants. A water system that does not follow EPA's monitoring methodology or schedule is in violation and may be subject to legal action.
Percentage	A way of expressing a number as a fraction of 100 (percent meaning "per hundred").
Percentile	A value on a scale that indicates the percent of a distribution equal to or below it. For example, a score at the 95th percentile is equal to or higher than 95 percent of the scores.
Pathogen	A disease-causing organism.
Population-based	Pertaining to the general population as defined by geopolitical boundaries such as nation, state, county and ZIP code.

Public health	The art and science dealing with preventing disease, prolonging life and promoting health through organized efforts of society including preventive medicine, sanitary and social services.
Public notification	An EPA advisory that a water system is required to distribute to affected consumers when the system has violated MCLs or other regulations. The notice advises consumers what precautions, if any, they should take to protect their health.
Public water system (PWS)	Any water system that annually provides water to at least 25 people for at least 60 days. There are more than 170,000 PWSs providing water from wells, rivers and other sources to about 250 million Americans. There are differing standards for PWSs of different sizes and types.
PWS	See public water system.
Relationship	A way in which people and things may be associated with each other, either real or suspected, that describes their interaction. Relationship or association does not imply causation.
Risk factor	An exposure, activity, physical characteristic or genetic predisposition that may increase the chance of developing a particular health outcome.
Sample	Water analyzed for presence of EPA-regulated drinking water contaminants. Depending on the regulation, the EPA requires water systems and states to take samples from source water, from water leaving the treatment facility or from the taps of selected consumers.
SDWA	Safe Drinking Water Act. Passed by the U.S. Congress in 1974 to protect public health by regulating the nation's public drinking water system. SDWA authorizes the U. S. Environmental Protection Agency (EPA) to set national health-based standards for drinking water to protect against both naturally occurring and man-made contaminants that may be found in drinking water.
SDWIS	The Safe Drinking Water Information System contains information about public water systems and their violations of EPA's drinking water regulations, as reported to EPA by states. It does not contain specific sampling or monitoring data.

SDWIS/State	Safe Drinking Water Information System/State Version helps states manage information necessary to supervise public drinking water systems by offering three major categories of information: inventory, sampling and monitoring data.
Secondary drinking water standards	Non-enforceable federal guidelines regarding cosmetic effects (such as tooth or skin discoloration) or aesthetic effects (such as taste, odor or color) of drinking water.
Source water	Water in its natural state, prior to any treatment for drinking.
Spatial	Geographic location; contrasted with temporal, which pertains to time.
Surface water	Water that systems pump and treat from sources open to the atmosphere, such as rivers, lakes and reservoirs.
Treatment technique	Required to reduce the level of a contaminant in drinking water.
TTHM	Total trihalomethanes are a widely occurring class of disinfection byproducts (see DBPs) that include chloroform, bromoform, bromodichloromethane and dibromochloromethane.
Violation	A failure to meet any state or federal drinking water regulation. (See MCL violation.)

Note: Sources for drinking-water specific terms were abstracted primarily from www.epa.gov/safewater/glossary.htm; 40 CFR 141.2; and the U.S. EPA Office of Ground Water and Drinking Water.

Reference links

Oregon Department of Human Services (DHS), Environmental Public Health Tracking (EPHT): *www.oregon.gov/DHS/ph/epht/*

U.S. Department of Health and Human Services (DHHS), Centers for Disease Control and Prevention (CDC), National Environmental Public Health Tracking (NEPHT) Program: *www.cdc.gov/nceh/tracking/default.htm*

U.S. Department of Health and Human Services (DHHS), Centers for Disease Control and Prevention (CDC), Agency for Toxic Substances and Disease Registry (ATSDR): *www.atsdr.cdc.gov/tfacts13.html*

U.S. Department of Health and Human Services (DHHS), National Institutes of Health (NIH), National Institute of Environmental Health Sciences (NIEHS): *www.niehs.nih.gov/health/topics/agents/lead/index.cfm*

U.S. Environmental Protection Agency (EPA). Drinking Water Requirements, National Primary Drinking Water Regulations: *www.epa.gov/safewater/contaminants/index.html#primary*

U.S. Environmental Protection Agency (EPA), Safe Water Program: *www.epa.gov/safewater/index.html*

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DHS Oregon Department of Human Services

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