Health Consultation

SUTHERLIN VALLEY GROUNDWATER ARSENIC STUDY

SUTHERLIN, DOUGLAS COUNTY, OREGON

Prepared by the
Oregon Public Health Division

JULY 17, 2009

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR Toll Free at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

SUTHERLIN VALLEY GROUNDWATER ARSENIC STUDY

SUTHERLIN, DOUGLAS COUNTY, OREGON

Prepared By:

Oregon Public Health Division
Environmental Health Assessment Program

Under a Cooperative Agreement with:
Public Health Service
Agency for Toxic Substances and Disease Registry
U.S. Department of Health and Human Services
Atlanta, Georgia

Foreword

The Environmental Health Assessment Program (EHAP) within the Oregon Public Health Division (PHD) has prepared this Health Consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services, Public Health Service. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and disease related exposures to toxic substances. This Health Consultation was prepared in accordance with ATSDR methodology and guidelines.

ATSDR and its cooperative agreement partners review the available information about hazardous substances at a site, evaluate whether exposure to them might cause any harm to people, and provide the findings and recommendations to reduce harmful exposures in documents called Public Health Assessments and Health Consultations. ATSDR conducts a Public Health Assessment for every site on or proposed for the National Priorities List (the NPL, also known as the Superfund list). Health Consultations are similar to Public Health Assessments, but they usually are shorter, address one specific question, and address only one contaminant or one exposure pathway. Another difference is that Public Health Assessments are made available for public comment, while Health Consultations usually are not. Public Health Assessments and Health Consultations are not the same thing as a medical exam or a community health study.

Public Health Assessments and Health Consultations include conclusions that categorize environmental contaminants and conditions according to the likelihood that they will harm people. These categories are called "Hazard Categories."

The 5 Hazard Categories

Urgent Public Health Hazard: This category is for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require rapid intervention to stop people from being exposed.

Public Health Hazard: This category is used for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Indeterminate Public Health Hazard: This category is used for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures. In other words, this category is used when there is not enough information to decide whether or not a condition at a site poses a public health hazard.

No Apparent Public Health Hazard: This category is used for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: This category is used for sites where there is evidence of an absence of exposure to site-related chemicals.

For more information about hazard categories, see ATSDR's website at: http://www.atsdr.cdc.gov/COM/hazcat.html.

Table of Contents

Summary

The Environmental Health Assessment Program (EHAP), part of the Oregon Department of Human Services (DHS) Office of Environmental Public Health, prepared this health consultation in order to evaluate the public health implications of naturally-occurring arsenic in groundwater in the Sutherlin Valley area of southwest Oregon. The form of arsenic referred to in this report is inorganic arsenic. Historical studies in this area found arsenic in privately-owned groundwater wells at levels that posed health risks to people who used this well-water for drinking and cooking purposes. During EHAP's assessment of Red Rock Road in 2005, the Douglas County Health Department informed EHAP staff of these historical studies. In 2008, EHAP collaborated with the Oregon Environmental Public Health Tracking (EPHT) Program and other partners to conduct the Sutherlin Valley Groundwater Arsenic Study. The study's goals were to investigate the occurrence of naturally-occurring arsenic in Sutherlin Valley groundwater, and evaluate the human health risks from exposure to arsenic in privately-owned wells.

Participants were recruited to the Sutherlin Valley Arsenic Study by offering 100 free well-water tests for arsenic and nitrates to residents in the Sutherlin, Oakland and Yoncalla zip codes in Douglas County, Oregon. A total of 124 samples were collected from 114 wells. None of the wells had nitrates at levels that exceeded environmental screening guidelines. Arsenic was detected in 29 wells at concentrations ranging from 1 - 460 ppb. Thirteen wells had arsenic at levels that exceeded the safe drinking water standard of 10 ppb, and the majority of these wells were located in the Nonpareil and Hinkle Creek area to the east of Sutherlin.

EHAP evaluated whether Sutherlin Valley residents could be exposed to unsafe levels of arsenic in groundwater by using their well-water for domestic purposes (particularly for drinking and cooking) and for irrigation purposes. The public water systems in the Sutherlin area obtain their water from surface water sources, and arsenic has not been detected in the Sutherlin, Oakland and Yoncalla city water systems over several years of monitoring. EHAP evaluated the risks for non-cancer and cancer health effects from short-term and long-term exposure to arsenic at concentrations in the range detected in this study. Based on its evaluation of the data collected in this study, EHAP concluded the following:

- Domestic wells with arsenic concentrations over 150 ppb pose an **urgent public health hazard** to residents who use this water for drinking or cooking purposes. At these levels, residents could experience harmful health effects from short- and long-term exposures to arsenic in water. EHAP identified four domestic wells in this study with arsenic concentrations exceeding this level.
- Domestic wells with arsenic concentrations up to 150 ppb pose a **public health hazard** to residents who use this water for drinking or cooking purposes. Residents could have increased risks for harmful health effects if they have long-term exposures to water with arsenic levels that are substantially higher than the safe drinking water standard of 10 ppb. Arsenic levels slightly higher than this

standard may not pose increased health risks; however, as a precaution, EHAP recommends that water with arsenic above 10 ppb not be used for drinking or cooking water. EHAP identified seven domestic wells in this study with arsenic concentrations exceeding 10 ppb.

- Domestic wells with arsenic concentrations at or below 10 ppb pose **no apparent public health hazard** to residents who use this water for domestic purposes, including for drinking and cooking. At these levels, EHAP did not find any increased risks for harmful health effects from short or long-term exposures to arsenic in water. EHAP identified 83 domestic wells in which no arsenic was detected and 16 domestic wells in which arsenic was detected between 1 and 10 ppb.
- Arsenic in irrigation wells at the levels measured in this study (up to 458 ppb) pose **no apparent public health hazard** to residents who use this water for occasional irrigation or recreational purposes. EHAP identified two irrigation wells in which no arsenic was detected and two irrigation wells with arsenic concentrations of 25 and 458 ppb.

Based on these findings, EHAP recommends that study participants with arsenic detected at concentrations above the drinking water standard of 10 ppb should not use their water for drinking or cooking. These homeowners should use an alternate water supply for drinking, cooking and washing fruits and vegetables (bottled water, or water treated by an approved system for removing arsenic). Sutherlin Valley residents (particularly those living in the Nonpareil/Hinkle Creek area) who have not had their water tested for arsenic should do so immediately. These residents should contact an accredited state laboratory for information on sample collection and testing (Appendix C).

Over the course of this study, EHAP collected a number of community concerns related to arsenic in groundwater, and other drinking water concerns. These concerns included:

- Safe uses of water with detectable levels of arsenic
- Concerns about other water contaminants and water quality issues, including mercury, hydrogen sulfide and iron bacteria
- Possibility of contamination from Red Rock Road and mine tailings
- Options for alternate water supplies, including bottled water and approved treatment systems that will remove arsenic
- Financial concerns related to using alternate water supplies
- General questions about well maintenance and well-water testing

EHAP has had several opportunities to address these concerns, including during the communication of individual testing results (via phone and by mail), follow-up with owners of wells with arsenic levels exceeding 10 ppb, a public meeting that was held in August 2008, and outreach through press releases, fax blasts to health care providers and an article in the county health department's news letter. EHAP will continue to work with the Douglas County Health Department and other partners to address these community concerns, and facilitate the implementation of the recommendations outlined in this document.

Purpose and Health Issues

The Environmental Health Assessment Program prepared this health consultation to evaluate the human health risks from potential exposure to naturally-occurring inorganic arsenic in groundwater wells in the Sutherlin Valley area of southwest Oregon. EHAP is part of the Oregon Department of Human Services Public Health Division and evaluates the human health risks of exposure to environmental contaminants in Oregon through a cooperative agreement with ATSDR.

Historical studies have found high levels of naturally-occurring arsenic in groundwater wells in some parts of Douglas County, Oregon. People who use these wells for domestic purposes (particularly for drinking or cooking water) could be exposed to unsafe levels of arsenic, which is known to cause harmful cancer and non-cancer health effects. In 2008, EHAP collaborated with a number of partner programs and agencies on a study to measure arsenic levels in privately-owned wells in the Sutherlin Valley area of Douglas County. The data from this study were used to determine if private well-owners are being exposed to naturally-occurring arsenic at levels that could harm their health. These data also expand the available environmental information on the occurrence of arsenic in Oregon's groundwater.

Site Background

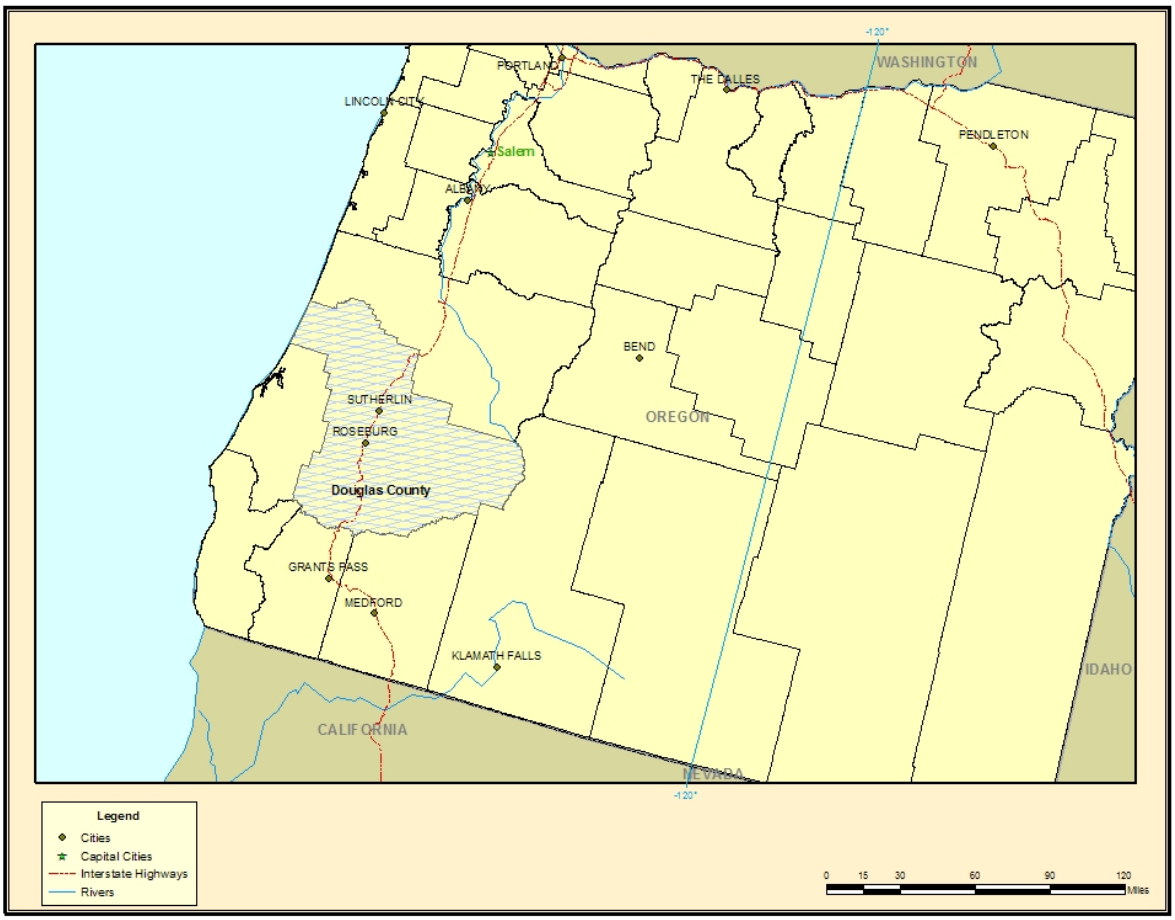
Many western states, including Oregon, have higher levels of arsenic in groundwater compared to other parts of the country. This arsenic often comes from natural sources such as soil, eroding rock formations, and other geologic features[1]. In some areas of Oregon, the arsenic levels in groundwater exceed 10 ppb, which is the Environmental Protection Agency's safe drinking water standard (called the maximum contaminant limit, or MCL). A US Geological Survey study found that nearly 25% of 249 groundwater samples collected in eight counties in Oregon had arsenic levels that exceeded the MCL, with some samples exceeding 1,000 ppb arsenic[2]. These data indicate that the groundwater concentrations of arsenic in some parts of Oregon are at levels that could pose health risks to individuals and communities who consume this water.

Public water systems are required to monitor and regulate the amounts of contaminants (including arsenic) in drinking water. However, private well owners in Oregon are not required to test their well-water. Oregon law currently requires that wells on properties involved in real estate transactions must be tested for nitrate and total coliform bacteria, and this requirement may be expanded to include testing for arsenic. However, many private well owners may not be aware of the quality and safety of their local groundwater sources and unknowingly be exposed to unsafe levels of arsenic or other contaminants in their water.

Douglas County is located in southwestern Oregon (Figure 1). In 2007, the population of Douglas County was estimated to be 104,675, which represented approximately 2.8% of Oregon's total population[3]. The Sutherlin Valley area is located north of the county

seat of Roseburg. In 2007, the city of Sutherlin had an estimated population of 7,660, Oakland had a population of 940 and Yoncalla had a population of 1,110. Over one-half of Douglas County's population lives in unincorporated areas. Manufacturing jobs, particularly in the lumber and wood industries, account for a large percentage of the county's jobs. Unemployment rates in Douglas County are higher compared to the State of Oregon (8.6% vs. 5.7% in July 2008)[4]. Data from the U.S. Census show that the median household income in Douglas County was below the average for the State of Oregon in 2004 ($36,041 compared to $42,568) and the percent of persons living below poverty was higher (15.0% compared to 12.9%)[5].

Figure 1. Map of Douglas County, Oregon.



At least two historical studies were conducted in Douglas County during the 1970s that examined the occurrence of arsenic in groundwater[6, 7]. These studies sought to determine the magnitude of the problem (the range of arsenic concentrations detected and the types of water sources affected), whether there were geographic locations that appeared to be more affected than others, and whether there were geologic features (such as volcanic rock formations) that might be related to any higher risk areas found. The historical studies found private groundwater wells with arsenic concentrations that

exceeded 300 ppb, and identified some geographic locations that appeared to be high risk areas, including the Nonpareil and Hinkle Creek areas located east of the city of Sutherlin. The high arsenic levels in these areas appeared to be associated with geologic formations that contained rich deposits of mercury, and the studies' authors noted that there were several mercury mines in these areas.

The public water systems in the Sutherlin area obtain their water from surface water sources, and arsenic has not been detected in the Sutherlin, Oakland and Yoncalla city water systems over several years of monitoring [8]. Therefore, people who obtain their domestic or irrigation water supply from these public water systems would not be exposed to arsenic in water. However, people living in areas that are not served by these systems most probably rely on privately-owned wells for their water supply. Data from the 1990 Census indicated that privately-owned wells were the primary source of water for approximately 20% of households in the Sutherlin area. However, there are limited data on the number of households that currently rely on privately-owned wells, or more recent measurements of arsenic in the area's groundwater.

Site History

In 2005, EHAP became involved in an investigation of the Red Rock Road site in Douglas County, OR. The purpose of the investigation was to evaluate whether people were exposed to unsafe levels of arsenic and mercury from mine tailings that were used to build a road near the city of Sutherlin. During the investigation, staff from the Douglas County Health Department informed EHAP of historical studies that showed elevated levels of arsenic in private wells in the Sutherlin Valley. The arsenic in these wells was believed to be from natural sources such as geologic formations containing high concentrations of mercury and arsenic and not related to arsenic contamination from Red Rock Road. At the time, EHAP was unable to investigate whether arsenic in groundwater posed a health risk to private well-owners in the area. In the Public Health Assessment report on Red Rock Road (released in 2007), EHAP recommended that Sutherlin Valley residents with private domestic wells have their wells tested for arsenic. In 2008, EHAP and the Oregon Environmental Public Health Tracking Program (EPHT) initiated a study to collect data on arsenic levels in private wells in the Sutherlin Valley.

The EPHT program, which is also within the DHS Office of Environmental Public Health, is part of a nationwide effort to develop networks that integrate data on environmental hazards and exposures to human health outcomes. This information can be used to better understand how environmental contaminants and conditions affect human health, and guide public health efforts to prevent harmful exposures[9]. The EPHT network is being built through a collaborative process that utilizes input and information from a number of local, state and national partners and stakeholders.

The Oregon Department of Environmental Quality (DEQ) is an important source of environmental monitoring data for EPHT. However, because there have been few studies on the occurrence of naturally-occurring arsenic in Oregon's groundwater, the available environmental data on arsenic are limited. Therefore, this study provided an opportunity

to expand EPHT's network by providing data on an environmental contaminant that is known to be toxic to humans. In addition to providing funding for the study, EPHT provided staff expertise on study design, interpretation of results and communication of findings.

The Sutherlin Valley Arsenic Study provided an opportunity for EHAP and EPHT to collaborate with a number of local and state agencies, including Oregon DEQ, the Oregon Drinking Water Program, and the Douglas County Health Department. EHAP and EPHT were also able to provide health education and outreach well-water testing and safety to private well owners, and on arsenic-related health effects to health care providers.

Study Recruitment and Sample Collection

Participation in the Sutherlin Valley Arsenic Study was voluntary. EHAP recruited participants by offering free well-water testing for arsenic and nitrates. Data on mercury were not collected as part of this study because of budget considerations and historical information that suggest that mercury does not affect the groundwater quality in this area (discussed in more detail in the Community Concerns section on page 19). However, data on nitrate levels were collected as an incentive to encourage participation in the study. High nitrate levels are a concern for human health and water quality in areas with agricultural activity; the sources of nitrates in these areas are usually fertilizers, animal and livestock waste, and septic systems.

Free well tests were offered to 100 private well owners in the Sutherlin, Oakland and Yoncalla areas (zip codes 97479, 97462 and 97499 respectively). The well-water testing was advertised through a press release, newspaper ads in three local newspapers (North County News, the Roseburg News Review and the Umpqua Shopper), and postings on a local TV station's community calendar. The recruitment period was approximately one month. A total of 105 residents in the Sutherlin area were recruited to the study. These well-owners were mailed consent forms and a questionnaire to gather information to assist in sample collection (such as number of wells on property, location of wells, use of filtration systems, etc.).

The Oregon DEQ collected 124 well water samples from 114 wells between June 9-June 18th (including field duplicate samples and samples collected before and after water treatment). Table 1 provides a summary of the wells sampled for this study. The majority of wells sampled were used for domestic purposes, while a small number were used only for irrigation water. All well water samples were tested for arsenic and nitrates at the DEQ Laboratory in Hillsboro, OR. Arsenic was detected in 29 of the 114 wells sampled, and the maximum concentration detected in this study was 460 ppb. Eleven of the 13 wells that exceed the MCL were used for domestic purposes.

Table 1. Summary of wells sampled for the Sutherlin Valley Arsenic Study.

Total Samples Collected	124
Total Wells Sampled	114
Number Domestic Wells	110
Number Irrigation Wells	4
Wells by Zip code	
97479 (Sutherlin)	45
97462 (Oakland)	54
97499 (Yoncalla)	15
Number of Wells with Arsenic Detections	29
Arsenic Concentrations (ppb)	
1-10	16
11-50	6
51-100	2
201-300	2
>400	3
Maximum Detection in Domestic Well	460 ppb
Maximum Detection in Irrigation Well	458 ppb

Geographic Distribution of Wells

The wells that were sampled in this area were distributed throughout the three zip code study area. The majority of wells sampled were in the Oakland area (97462) and the Sutherlin area (97479), with the smallest representation in the Yoncalla area (97499). Figure 2 shows the distribution of all wells sampled as part of this study.

The 29 wells with arsenic detections were distributed throughout the study area. However, 11 of the 13 wells with arsenic levels above 10 ppb were located to the east of Sutherlin in the Hinkle Creek and Nonpareil area. This confirms the findings from historical studies that identified this as a higher risk area for high arsenic concentrations in groundwater. This area is near geologic fault zones and formations that contain high concentrations of arsenic and mercury, which are the likely sources for the arsenic in the area's groundwater. Figure 3 shows a more detailed map of this area. The arsenic concentrations appear to increase traveling east along Nonpareil Road away from the city of Sutherlin. There appears to be a cluster of wells with high arsenic detections in the area near Bonanza Mine and Nonpareil Mine (which were both former mercury mines). The highest arsenic concentrations were detected in the Hinkle Creek area.

Figure 2. Map of wells sampled for Sutherlin Valley Arsenic Study.

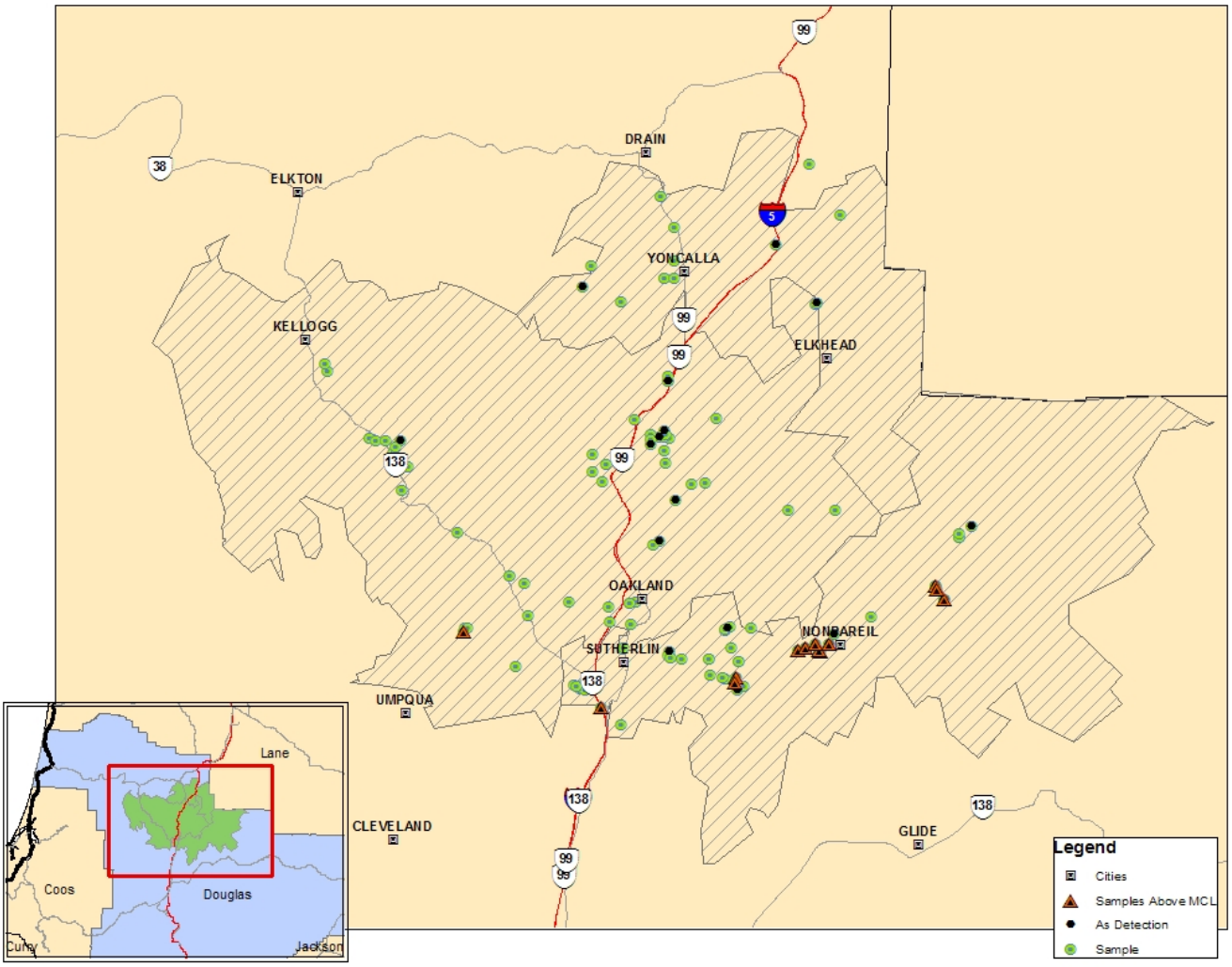
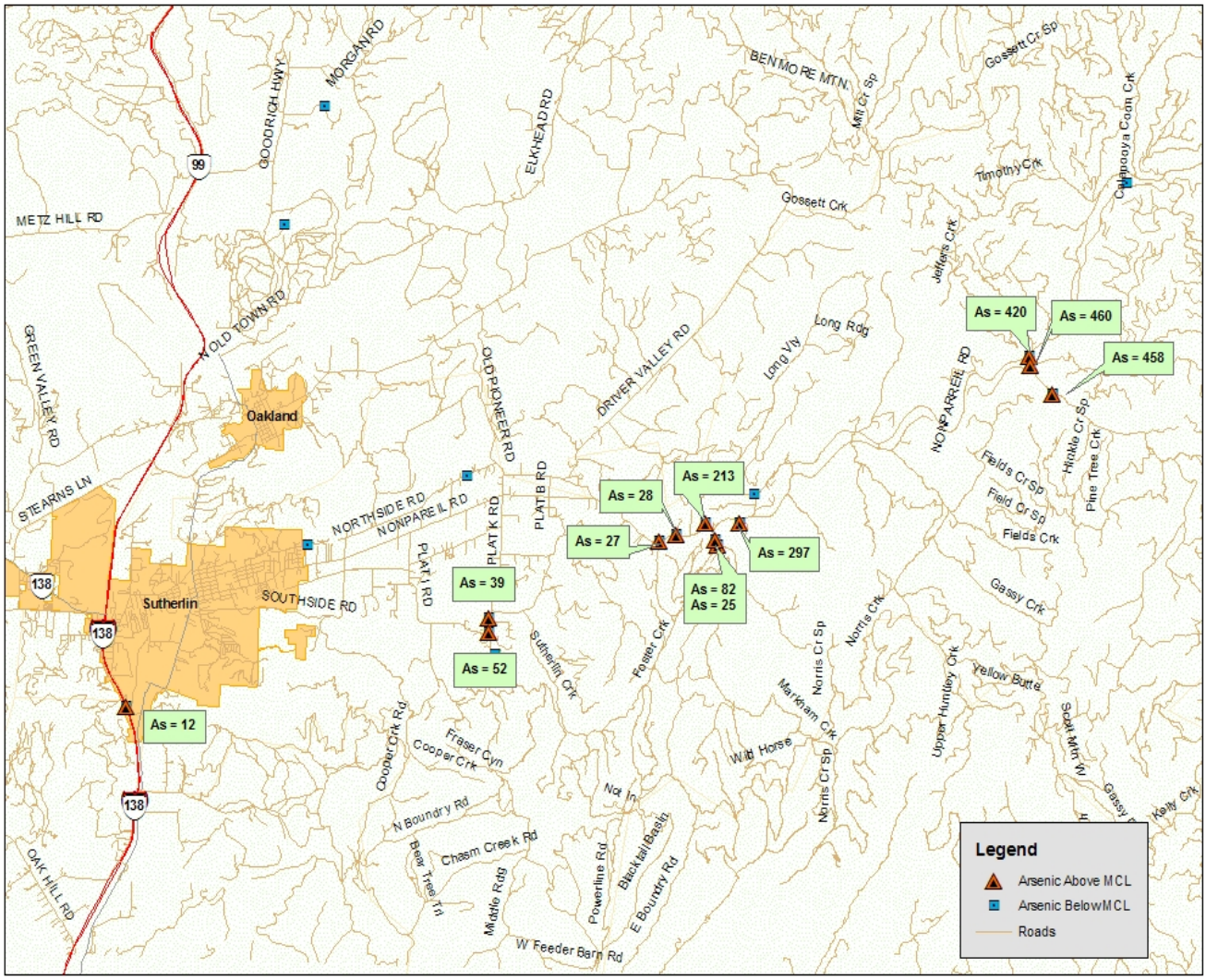


Figure 3. Detailed map of wells sampled in the Nonpareil and Hinkle Creek area.



Discussion

Most people in the U.S. are exposed to low levels of arsenic on a daily basis through food, water and air. While most people do not come into contact with harmful levels of arsenic, some people can be exposed to levels that can cause serious health effects. This section describes how EHAP evaluated whether private well-owners in the Sutherlin Valley are being exposed to unsafe levels of naturally-occurring arsenic in their groundwater.

Information about Screening Guidelines

As part of its health assessment process, EHAP uses screening guidelines (or comparison values) to identify the contaminants of potential health concern at a site. ATSDR and EPA develop these guidelines based on knowledge about the health risks from exposure to a chemical, including information about the types of health effects that have been observed in human and animal studies, the amounts of a contaminant that have resulted in these effects, and the strength of the scientific evidence. Screening guidelines do not represent a threshold for adverse health effects (i.e., exceeding a screening guideline does not mean that there will be an increased risk of harmful health effects). Instead, these guidelines are a tool to efficiently screen out the contaminants at a site that are not expected to result in increased health risks, and screen in the contaminants that require further evaluation.

In some cases, the screening guideline for a contaminant is different, and sometimes more conservative, than the regulatory or clean-up standards used by federal and state agencies. This is because regulatory standards (such as the MCLs for public drinking water systems) are based on considerations of human health and also considerations about the costs and available technology needed to detect, monitor or remove a contaminant from the environment. Though regulatory standards may be less conservative than screening guidelines, they are set at levels that are protective of human health.

Comparison to Environmental Screening Guidelines

Arsenic and nitrates were the only contaminants that were tested for in the Sutherlin Valley Groundwater Arsenic Study. As a first step, EHAP used environmental screening guidelines to determine if the groundwater concentrations of arsenic or nitrates were at levels that could pose risks to human health. The guideline for arsenic is the Cancer Risk Evaluation Guideline (CREG), which is the concentration of arsenic in water that could result in a slight increase in cancer risk (or one additional cancer case in one million persons exposed over a lifetime). The guideline for nitrates is maximum contaminant level goal (MCLG), which is EPA's drinking water health goal, and is the level at which there are no anticipated adverse health effects for the most sensitive human populations. A contaminant is not expected to cause harmful health effects if its maximum concentration is below its environmental screening value. Contaminants that exceed their

environmental screening values will not necessarily pose a public health risk, but require further evaluation.

Table 2 summarizes the environmental guideline comparison for the Sutherlin Valley Arsenic Study. Arsenic was detected in 29 of the 114 wells sampled. All detected concentrations of arsenic (which ranged from 1-460 ppb) exceeded the environmental screening guideline of 0.02 ppb. Nitrates/nitrites were detected in 64 of the 114 wells. None of the samples (with detectable concentrations ranging from 5.3 – 4,480 ppb) exceeded the environmental screening guideline of 10,000 ppb. Arsenic was the only contaminant of potential health concern identified in this study, and was further evaluated to determine any health risks to exposed residents.

Table 2. Environmental guideline comparison for the Sutherlin Valley Arsenic Study.

Contaminant	Detection Frequency*	Concentration (ppb) Range	Screening Value (ppb)	Screening Value Source	Above Screening Value?
Arsenic	29/114	ND – 460	0.02	CREG	Yes
Nitrates/Nitrites	64/114	ND – 4,480	10,000	MCLG	No

*Includes field duplicate samples.
Key: ND = Non-Detect; ppb = parts per billion; CREG = Cancer Risk Evaluation Guideline; MCLG = Maximum Contaminant Level Goal

Exposure Pathway Analysis

A person must come into contact with an environmental contaminant in order for there to be any possibility of health risks from that contaminant. Arsenic was the only contaminant of potential health concern identified in the Sutherlin Valley Arsenic Study. To determine how Sutherlin residents could come into contact with arsenic in the environment, EHAP identified potential exposure pathways by evaluating five key elements:

- A source for the contaminant(s) or release (Source)
- Movement of contaminants in the environment (Fate and Transport)
- A location or area where people can come into contact with contaminants (Point of Exposure)
- A population that can come into contact with contaminants (Potentially Exposed Population)
- A way for people to come into physical contact with contaminants (Route of Exposure)

If all five elements in an exposure pathway are known or believed to be present, the contaminants in that pathway are further evaluated for potential risks to human health. If any of these five elements are known to be missing, people would not be exposed through that pathway and it would be eliminated from further analysis. EHAP identified two completed exposure pathways for the Sutherlin Valley Groundwater Arsenic Study (Table 3): exposure to arsenic in well-water used for domestic purposes, and exposure to arsenic in well-water used for irrigation/recreational purposes. While historical studies

have shown that Sutherlin Valley residents were exposed to arsenic in their well-water in the past, the data collected in this study were used to evaluate current exposures.

The source of arsenic in both pathways is from natural geologic materials. Arsenic moves from these sources to privately-owned wells through groundwater, and affected residents come into contact with contaminated groundwater through taps, faucets, sprinklers and other exposure points. Residents who use water from private wells for domestic (drinking/cooking) or irrigation purposes are expected to have the most exposure, but workers, visitors or transients who use these wells are also potentially exposed populations.

Table 3. Exposure Pathway Analysis for the Sutherlin Valley Arsenic Study.

Pathway	Source	Fate and Transport	Point of Exposure	Potentially Exposed Population	Route of Exposure	Time Frame
Arsenic in Domestic Well-Water	Arsenic in geologic materials	Groundwater (Private Domestic Wells)	Residences (Taps/other water source points)	Residents/ workers/ transients using private wells	Ingestion	Past Present Future
Arsenic in Irrigation Well-Water	Arsenic in geologic materials	Groundwater (Private Irrigation Wells)	Taps, sprinklers, hoses	Residents/ workers/ transients using irrigation wells	Ingestion	Past Present Future

The primary route of exposure for arsenic in groundwater is through ingestion. Residents with contaminated domestic wells could ingest arsenic by drinking water or beverages prepared with contaminated water, eating foods that have been contaminated while washing or cooking with contaminated water, or accidentally swallowing water during activities such as bathing or showering. Residents with contaminated irrigation wells could be exposed by accidentally swallowing water during activities such as gardening or recreational activities. Arsenic does not easily evaporate from water to air, so inhalation would not be a significant route of exposure. Arsenic is not easily absorbed by the skin, so dermal exposures through washing, bathing or other skin contact would not be a major route of exposure.

Sutherlin Valley residents could be exposed to arsenic in groundwater through other exposure pathways. For example, if water with high concentrations of arsenic is used for irrigation or gardening, arsenic can accumulate in soil over time and potentially reach toxic levels. This could pose health risks to residents who accidentally ingest or inhale contaminated soil, and is a particular concern for children. Because the Sutherlin Valley Groundwater Arsenic Study was focused on arsenic levels in groundwater, EHAP did not have the soil data needed to evaluate this or other potential exposure pathways.

Health Effects Evaluation

After identifying the ways in which Sutherlin residents could be exposed to arsenic in groundwater, EHAP examined whether these exposures could potentially result in harmful health effects. As a first step, EHAP calculated an exposure dose using information such as the concentration of arsenic in water and estimates of people's water consumption rates and body weight. The exposure dose is an estimate of how much a person has been exposed to a contaminant over a given period of time. People with higher levels of exposure are expected to have a higher exposure dose. Therefore, an adult exposed to 100 ppb of arsenic in water would be expected to have a higher dose than an adult exposed to 10 ppb of arsenic in water, assuming that they are of similar weight, drink the same amount of water, and have been exposed for the same amount of time. The exposure dose is reported as milligrams of arsenic per kilogram of body weight per day, or mg/kg/day.

EHAP calculated exposure doses for children (6 years or younger) and adults (18 years or older) separately. In calculating the exposure doses, EHAP used as much site-specific information as was available in order to accurately represent the residents' exposures. This information included the arsenic levels measured in this study and whether wells were used for domestic or irrigation purposes (see Appendix B). However, EHAP did not have information on some important factors, which resulted in some uncertainties in estimating the exposure dose. For example, it was difficult to determine how long people have been exposed to arsenic in groundwater wells in Sutherlin. During study recruitment, some residents indicated that they have lived in the area for several decades, while others had recently moved into the area. In addition, residents' exposures would have changed if they moved in or out of the Sutherlin area, or if they stopped using their wells for their domestic water supply during the time they lived in their home.

In cases where these data gaps existed, EHAP made conservative assumptions about residents' exposures in order to represent a "worst-case scenario" for exposure to arsenic. This is a health-protective approach that likely results in overestimates of the exposure doses at this site. For example, EHAP assumed that an adult living in the Sutherlin Valley would have been exposed to arsenic in their water for 350 days a year for 30 years. Further, children and adults were respectively assumed to drink 1.5 and 2.3 liters of contaminated water a day, which represents an upper-bound estimate of water consumption in the U.S. population. The exposure assumptions used in this health consultation, and the formulas used to estimate the exposure doses, are shown in detail in Appendix B. Because of the wide range of arsenic levels detected at this site (from 0 – 460 ppb), EHAP calculated the exposure doses at several different concentrations of arsenic in this range.

Evaluation of Non-Cancer Health Effects

EHAP compared the exposure doses to health guidelines to determine if Sutherlin residents were at risk for non-cancer health effects from arsenic exposure. The health guidelines used in this evaluation are based on information from studies on health effects

observed in studies of animals and humans who have been exposed to arsenic. The information from these studies is used to determine the lowest amounts of a substance that have resulted in adverse health effects (the Lowest Observed Adverse Effect Level, or LOAEL) and the highest amounts of a substance that have resulted in no adverse health effects (the No Observed Adverse Effect Level, or NOAEL). ATSDR applies a number of safety factors to the LOAEL and NOAEL to derive non-cancer health guidelines such as the Minimal Risk Level (MRL). These safety factors result in the health guidelines being lower than the LOAEL or NOAEL. The MRL represents the daily dose of a contaminant that people could be exposed to for a specified period of time without experiencing any health effects.

ATSDR has developed health guidelines for acute (short-term, or 14 days or less) and chronic (long-term, or 365 days or more) exposures to arsenic based on health effects seen in studies of people who were exposed to arsenic. The acute MRL for arsenic is 0.005 mg/kg/day, which is 10 times lower than the acute LOAEL of 0.05 mg/kg/day. The acute LOAEL is based on the doses that were shown to cause harmful health effects during an outbreak of arsenic poisoning from contaminated soy-sauce in Taiwan. The poisoned cases were estimated to have consumed 0.05 mg/kg/day of arsenic over the course of 2-3 weeks. The critical health effects that were most commonly observed in these cases included swelling of the face, gastrointestinal symptoms (such as nausea, vomiting and diarrhea) and respiratory symptoms; other health effects included anemia, lesions on the liver and eyes, and abnormal heart rhythms[10]. The critical health effects in the poisoned individuals subsided after they stopped consuming the contaminated soy-sauce.

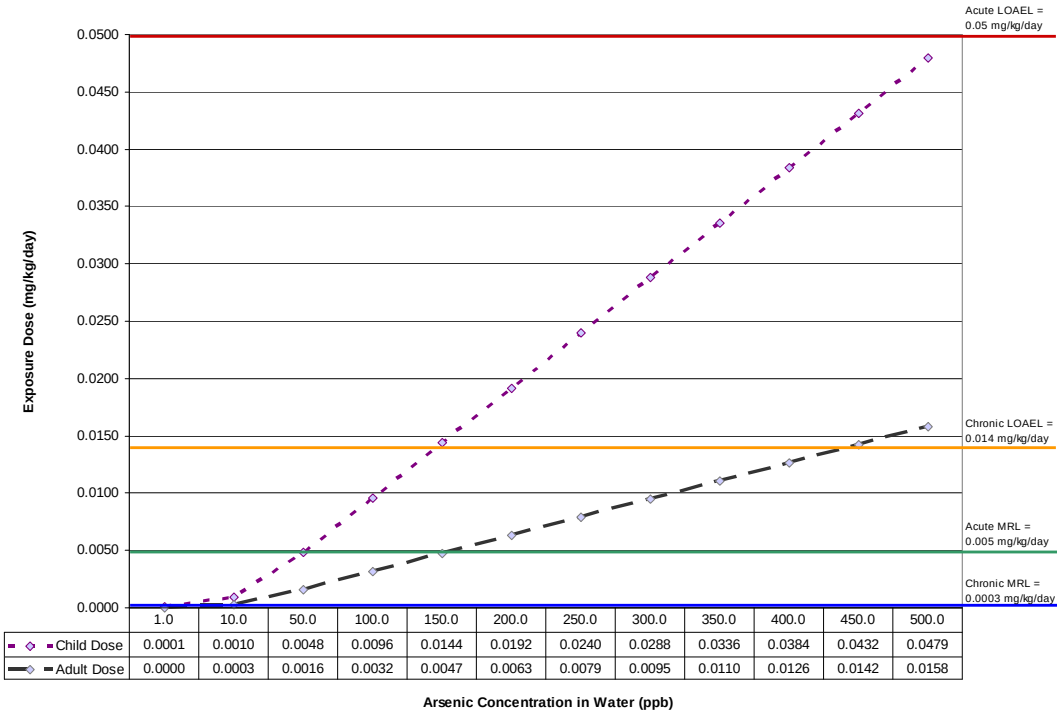
The chronic MRL for arsenic is 0.0003 mg/kg/day, which is approximately 47 times lower than the chronic LOAEL for arsenic (0.014 mg/kg/day), and three times lower than the NOAEL (0.0008 mg/kg/day). These guidelines are based on studies of farmers in Taiwan who had long-term exposures to high levels of arsenic in well-water. Skin lesions and other skin effects (such as thickening and hyperpigmentation) were the most commonly observed health effects in the exposed farmers, and occurred at doses as low as 0.014 mg/kg/day. Farmers who were exposed to higher levels of arsenic for longer periods of time were more likely to have skin lesions than those with lower levels and duration of exposure[10].

To determine if Sutherlin residents were at risk for non-cancer health effects, EHAP compared the child and adult exposure doses to the acute and chronic MRLs for arsenic. There would be no risk for non-cancer health effects if the exposure doses were less than the MRLs. However, if the exposure dose exceeded an MRL, the risk for non-cancer health effects was further evaluated by comparing the exposure dose to the LOAEL. There potentially could be an increased risk for harmful health effects if the exposure dose is less than 10 times below the LOAEL.

EHAP calculated the exposure doses for people who use their well water for domestic purposes, assuming that children and adults would respectively consume 1.5 and 2.3 liters of water per day. Figure 4 shows the child and adult exposure doses at arsenic

concentrations in water ranging from 1-500 ppb, along with the acute and chronic health guidelines for arsenic.

Figure 4. Comparison of adult and child exposure doses to health guidelines for arsenic.



	1.0	10.0	50.0	100.0	150.0	200.0	250.0	300.0	350.0	400.0	450.0	500.0
Child Dose	0.0001	0.0010	0.0048	0.0096	0.0144	0.0192	0.0240	0.0288	0.0336	0.0384	0.0432	0.0479
Adult Dose	0.0000	0.0003	0.0016	0.0032	0.0047	0.0063	0.0079	0.0095	0.0110	0.0126	0.0142	0.0158

Some key findings from the health guideline comparison are summarized below:

- The lowest detected level of arsenic in the Sutherlin Valley Arsenic Study was 1 ppb. At this concentration, both the child and adult exposure doses are below the acute and chronic MRLs for arsenic, and there are no expected health risks.
- The safe drinking water standard for arsenic is 10 ppb. At this concentration, the adult exposure dose is equal to, and the child exposure dose exceeds, the chronic MRL of 0.0003 mg/kg/day. The child exposure dose is 15 times lower than the chronic LOAEL of 0.014 mg/kg/day. Therefore, it is unlikely that adults or children who consume water with 10 ppb arsenic would experience any harmful health effects.
- At 15 ppb, the child exposure dose is less than 10 times below the chronic LOAEL. Children who drink water with 15 ppb arsenic for a year or longer could be at increased risk for non-cancer health effects.
- At approximately 45 ppb, the adult exposure dose is less than 10 times below the chronic LOAEL. Adults who drink water with 45 ppb arsenic for a year or longer could be at increased risk for non-cancer health effects.
- At 150 ppb of arsenic, the child exposure dose is equal to the chronic LOAEL, which is the level at which harmful health effects were seen in people with long-term exposures. The child dose is only three times below the acute LOAEL;

therefore, children who drink water with 150 ppb arsenic for short periods of time could be at increased risk for harmful health effects.

- At 200 ppb of arsenic, the adult dose is only seven times below the acute LOAEL. Adults who drink water with these arsenic concentrations for 14 days or less could be at increased risk for harmful health effects.
- The highest concentration of arsenic detected in the study was 460 ppb. At this concentration, the child exposure dose is three times higher than the chronic LOAEL, and only slightly lower than the acute LOAEL. The adult exposure dose is approximately equal to the chronic LOAEL, and only four times lower than the acute LOAEL. People exposed to these arsenic concentrations for short or long periods of time could experience serious health problems.

People who use water from domestic wells face increased risks for harmful health effects as arsenic concentrations in water rise above the safe drinking water standard of 10 ppb. People, and especially children, who drink water with the highest concentrations of arsenic detected in this study could develop serious health problems from short or long-term exposures.

Evaluation of Cancer Risks

EHAP also evaluated whether Sutherlin residents could be at increased risk for cancer from exposure to arsenic in private wells. Cancer risks are evaluated by first examining if there is scientific evidence that a substance causes cancer, and then determining if exposures at a site could theoretically result in increased cancer risk. The EPA, the National Toxicology Program and the International Agency on Research of Cancer classify substances in terms of whether they are known, probable, possible or unlikely carcinogens. These agencies classify arsenic as a known human carcinogen based on studies in humans and animals. Exposure to inorganic arsenic has been found to increase the risk for cancers of the skin, lung, bladder, kidney, liver and prostate. A person's risk for developing cancer depends on how much arsenic a person is exposed to, how long a person is exposed, and factors such as diet, smoking, occupational exposures and other lifestyle factors.

For known or possible carcinogens, the EPA has developed cancer slope factors (CSF) as an estimate of a substance's potential to result in additional cancer cases in a population. The CSF is used to calculate a theoretical cancer risk, which is an estimate of the number of additional cancer cases that would occur if a population was exposed to a contaminant given the assumed exposure conditions at a site. It is important to note that the theoretical cancer risk does not predict a person's actual risk of developing cancer. Instead, it is a way for regulatory and public health officials to identify potential risks from chemical exposures and prioritize actions to prevent harmful exposures.

The theoretical cancer risk is calculated using the CSF and the exposure dose (see Appendix B). Any exposure to a carcinogen is assumed to have some risk, so the theoretical cancer risk can never be zero. Exposures are described in terms of having slight, low, moderate or high cancer risks. For example, exposures that could cause one

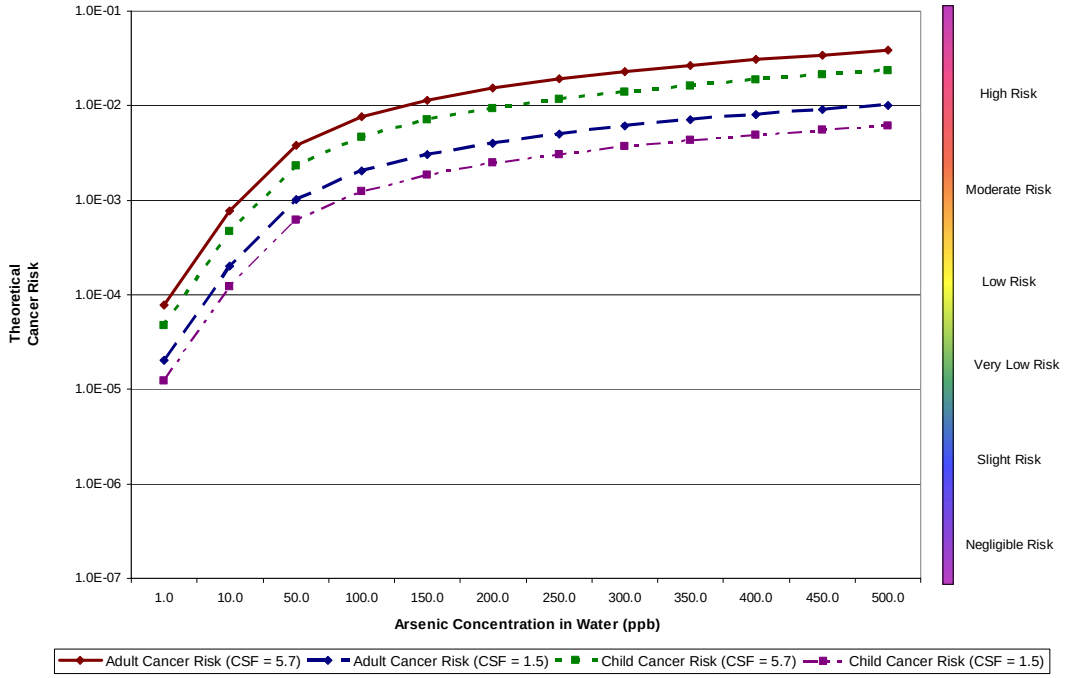
additional case of cancer in a population of one million are considered to have a slight cancer risk, while exposures that could cause one additional case in 10,000 have a low cancer risk.

ATSDR has developed an environmental screening guideline called the Cancer Risk Evaluation Guideline (CREG), which is the concentration of a substance in a specific media that could result in a one in one million increased cancer risk (or slight cancer risk). All detected concentrations of arsenic in this study (which ranged from 1 – 460 ppb) exceed the CREG for arsenic in water, which is 0.02 ppb. Therefore, EHAP further evaluated the cancer risks at this site to determine if they posed unacceptable cancer risks to Sutherlin residents. Because of the strength of evidence that exposure to arsenic can cause cancer, EHAP considered exposures that exceeded a low level of cancer risk to pose higher than acceptable risks to Sutherlin residents.

EHAP estimated the theoretical cancer risk using the CSF for arsenic and assuming that children would be exposed to arsenic in water for six years and adults would be exposed for 30 years. The current CSF for arsenic of 1.5 per mg/kg/day is based on studies of arsenic exposure and risks for developing skin cancer. However, there have been recommendations to base the CSF on risks for lung and bladder cancers, which are considered more serious endpoints than skin cancer[11]. The CSF for lung and bladder cancers combined is 5.7 per mg/kg/day[12]. EPA's final report on the revision of the cancer slope factor is slated to be released in 2009, and it is not known whether the current CSF will be changed. Therefore, EHAP calculated the cancer risks using both the current CSF of 1.5 per mg/kg/day and a CSF of 5.7 per mg/kg/day for lung and bladder cancers.

Figure 5 shows the cancer risks for children and adults who are exposed to arsenic in water at concentrations from 1-500 ppb. Children would have very low to low cancer risks at the lowest concentrations and moderate to high cancer risks at the highest arsenic concentrations detected in this study. Adults would have very low to low risks at the lowest concentrations and high cancer risks (more than one in 100 increased cancer risk) at the highest arsenic levels detected in this study. The cancer risks for children are lower than those for adults because children were assumed to be exposed for a shorter time period (six years compared to thirty years). In other words, the accumulated cancer risks from six years of exposure are expected to be lower than the risks from thirty years of exposure. The child and adult cancer risks exceed a low level of risk at arsenic concentrations that are higher than the drinking water standard of 10 ppb. In order to minimize any potential health risks, EHAP recommends that water exceeding 10 ppb not be used for drinking and cooking water.

Figure 5. Evaluation of child and adult cancer risks from arsenic exposure.



Irrigation Wells

EHAP also evaluated whether Sutherlin residents who use arsenic-contaminated water from irrigation wells could be at risk for harmful health effects. EHAP assumed that children or adults would accidentally swallow water from irrigation wells during activities such as gardening, swimming (assuming pools were filled from irrigation wells) and other recreational activities. The amount of water swallowed during these activities would be relatively small (conservatively assumed to be 0.1 liters/day for children, which is about 20 teaspoons), and would not occur on a regular basis.

At the highest concentrations of arsenic in irrigation wells (458 ppb), the maximum exposure doses were 0.00002 mg/kg/day for children and 0.0002 mg/kg/day for adults. These doses are below the acute and chronic MRLs for arsenic (0.005 mg/kg/day and 0.0003 mg/kg/day respectively), indicating that there would be no expected risks for non-cancer health effects. The theoretical cancer risks for children and adults at this concentration were slight to negligible, and did not pose an unacceptable level of cancer risk. Therefore, at the arsenic levels detected in this study, EHAP concluded that there were no expected health risks for people who use water from irrigation wells for occasional irrigation/recreational purposes only.

Children's Health Considerations

EHAP and ATSDR recognize that infants and children may be more vulnerable to exposures than adults in communities faced with contamination of their air, water, soil, or food. This vulnerability is a result of the following factors:

- Children are more likely to play outdoors and bring food into contaminated areas.
- Children are shorter, resulting in a greater likelihood to breathe dust, soil, and heavy vapors close to the ground.
- Children are smaller, resulting in higher doses of chemical exposure per body weight.
- The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

Because children depend on adults for risk identification and management decisions, EHAP is committed to evaluating their special interests in instances where their behaviors or sensitivity to contaminants could put them at greater risk.

Children can be exposed to arsenic in unique ways compared to adults. Arsenic exposures can occur during pregnancy, and infants also can be exposed during breastfeeding. Young children usually eat and drink less of a variety of foods than adults, and could ingest high amounts of arsenic if their formula or food are prepared with arsenic-contaminated water [10]. Younger children also are more likely to rely on a single water supply than adults (i.e., drink water mostly from home, versus drinking water from home and school/work). Young children tend to swallow large amounts of water during activities such as bathing, showering, or swimming. As mentioned earlier, soil concentrations of arsenic in the Sutherlin Valley could be high if arsenic-contaminated water has been used for irrigation, and this could be an additional source of exposure for children who may eat or inhale contaminated dust or soil.

EHAP found that children could be at increased risk for non-cancer health effects at lower concentrations of arsenic in water compared to adults. Children would develop the same health effects as adults, and there is evidence that long-term exposure to arsenic can result in decreased IQ scores in children. Pregnant women who are exposed to high levels of arsenic may be more likely to have spontaneous abortions and infants with low birth weight or birth defects.

Community Concerns

EHAP had several opportunities to collect community concerns during the Sutherlin Valley Groundwater Arsenic Study, including the recruitment and sampling period, during the communication of individual results, and during a public meeting held shortly after the laboratory results were confirmed. These concerns, and EHAP's response, are discussed in detail below.

1. EHAP received several inquiries about safe uses of water from residents with arsenic detected at levels below and above the drinking water standard of 10 ppb. These inquiries, and EHAP's recommendations, are summarized in Table 4.

Table 4. Oregon DHS recommendations for safe uses of water.

Safe Use of Water	Arsenic Concentration in Water	Notes
Drinking/Cooking Water (including making beverages, washing fruits and vegetables)	0-10 ppb	• Water with arsenic above 10 ppb should not be used for these purposes • Boiling water does not remove arsenic, and may result in higher concentrations of arsenic
Feeding/watering pets and animals	0-10 ppb	
Gardening/Irrigation Water	0-100 ppb	• Using water with high concentrations of arsenic for gardening or irrigating crops can result in the accumulation of arsenic in soil to potentially toxic levels. • Fruit/vegetables can take up and accumulate arsenic. Arsenic concentrations are usually highest at the roots and lowest in leaves/fruits. Fruiting plants (fruit trees, tomatoes, okra, corn, squash and beans) are least likely to accumulate arsenic in the edible parts, while root vegetables (potatoes, carrots and beets) are more likely. Leafy green vegetables can accumulate dust on the edible leaves, which can pose a health risk if the dust has high levels of arsenic. • Concerned residents can have a soil sample tested at a state-certified laboratory.
Bathing/laundering/ washing dishes/other home purposes	Below 500 ppb	• Arsenic is not easily absorbed by the skin, and does not "stick" easily to hard surfaces (such as dishes) or laundered clothing. • Children should be supervised during activities such as bathing or showering to minimize the amount of water that is accidentally swallowed.

2. EHAP also received questions related to DHS recommendations for alternate water supplies, filtration systems, and general well-water safety. EHAP provided the following recommendations related to these inquiries (Table 5).

Table 5. Information on alternate water supplies, filtration systems and well-water safety.

Concern	Recommendations	Notes
Alternate Water Supplies	Bottled Water	• Bottled water is a safe option to use for drinking and cooking if arsenic levels in well-water exceed 10 ppb. • Many of the homeowners with high arsenic levels were already using bottled water for their drinking water supply. EHAP recommended that these homeowners also consider using bottled water for cooking.
	Filtration Systems	• Not all water treatment or filtration systems will remove arsenic, and not all systems will effectively reduce very high concentrations of arsenic to levels that are safe for drinking or cooking. • Reverse osmosis systems, anionic exchange systems and iron oxide filter systems are the most commonly used systems for reducing/removing arsenic from water. • Residents who currently use or are considering using a treatment system to remove arsenic should ensure that these systems are certified by a recognized third-party testing organization that meets the standards established by the American National Standards Institute (ANSI) and NSF International.
Well Maintenance	Testing	• Residents may not need to test for arsenic on a regular basis. Arsenic levels in groundwater tend to remain relatively stable over time, though they can fluctuate depending on rainfall and other seasonal patterns. • Residents should have their well-water tested for coliform bacteria and nitrates at least once a year. • All tests should be done by a state-accredited laboratory. Residents can locate an accredited laboratory by calling the Department of Human Services Laboratory Accreditation Program at 503-693-4122 or visiting http://oregon.gov/DHS/ph/orelap/docs/acclab.pdf
	General	• In general, well-owners should make sure their wells, septic systems and drain fields are properly maintained. • Limit the amount of animal activity and chemical/pesticide use and storage in or near the well-house. • For information on general well-maintenance, visit the OSU Extension Services homepage: http://wellwater.oregonstate.edu

3. **Other water quality issues –** Sutherlin residents expressed concerns about these other water quality issues:
    A. **Mercury in water** – Several residents expressed concerns that there could be unsafe levels of mercury in their well water. These concerns were based on the location of former mercury mines in the area, and the apparent association between arsenic and mercury deposits in local geological formations. EHAP has limited data that indicate that mercury from natural sources is not a contamination issue in the area's groundwater. This is based on the following information:
        1. One of the historical studies examined whether mercury was present in Douglas County groundwater. No mercury was detected in the 864 samples collected in the study[7].
        2. All residences that were found to have arsenic levels above 10 ppb in the current study had samples collected for confirmatory testing in August 2008. These samples were analyzed for arsenic and other metals, including mercury. None of the samples collected from these 13 wells had mercury detected.
    B. **Aesthetic quality of water** – Some well-owners reported water quality issues that included the presence of hydrogen sulfide, which results in a rotten egg smell in the water, and iron bacteria, which results in discolored water that can stain fixtures and clothing. These issues are related to the aesthetic quality of water, and are not expected to result in health risks. However, many residents reported that they used bottled water because of these issues with their well-water.
4. **Contamination from Red Rock Road/mine tailings –** Some community members expressed concerns that the high arsenic levels in water were the result of contamination from Red Rock Road (which was built in the early 1900s with mine tailings rich in arsenic and mercury deposits). EHAP found that many of the wells with high arsenic concentrations are located near Red Rock Road. However, EHAP does not believe that dust from the road is the source of arsenic found in these wells for the following reasons:
        1. Arsenic from surface sources (such as Red Rock Road) is unlikely to affect groundwater sources. Surface water sources would more likely be affected by dust or soil that is disturbed during normal use of the road. However, the Sutherlin public water system (which obtains its water from surface water sources) has not detected any arsenic over several years of monitoring.
        2. Groundwater levels of arsenic would be expected to remain relatively stable over time. Data on the groundwater arsenic levels in the Sutherlin area are not regularly collected. However, EHAP noted similarities in the major findings of the current study and those from the studies conducted in the 1970s (which occurred after Red Rock Road was built). The concentrations in the current study were in the same range as those measured in the historical studies, and the same geographic hot spots were identified. This offers some evidence that the groundwater is the source of arsenic in these wells.
5. **Financial concerns** – Residents had questions and concerns about the financial costs of switching to alternate water supplies (bottled water and/or filtration systems). Some residents also noted that the cost of being hooked up to the Sutherlin city water supply was cost-prohibitive, even though there were water lines nearby.

Conclusions

Based on its evaluation of information collected for the Sutherlin Valley Arsenic Study, EHAP reached the following conclusions about the health hazards associated with exposure to arsenic in private-wells:

Table 6. Health hazard conclusions from Sutherlin Valley Arsenic Study.

Hazard Category	Well Type	Arsenic Concentration in Water	Number of Wells Identified	Length/Type of Exposure
Urgent Public Health Hazard	Domestic Wells	Above 150 ppb	4	Short (14 days or less) and long-term (365 days or more) exposure through drinking/cooking water
Public Health Hazard	Domestic Wells	Up to 150 ppb	7	Long-term exposure through drinking/cooking water
No Apparent Public Health Hazard	Domestic Wells	None Detected - 10 ppb	99	Short and long-term exposure through drinking/cooking water
No Apparent Public Health Hazard	Irrigation Wells	None Detected - 458* ppb	4	Short and long-term exposure through water used for occasional irrigation/recreational purposes

*Range of arsenic concentrations measured in this study. EHAP did not evaluate whether arsenic concentrations above 458 ppb could pose a health risk.

Recommendations

EHAP developed the following recommendations based on community health concerns and its assessment of the public health implications of arsenic in groundwater in the Sutherlin Valley:

1. EHAP should collaborate with the Douglas County Health Department to conduct outreach to inform Sutherlin Valley residents about the health implications of high arsenic levels in the area's groundwater. This outreach may include:
    - Providing information on well-testing to residents who have not had their wells tested
    - Providing information on DHS recommendations for safe water uses and alternate water supplies to study participants with arsenic detected at concentrations above the drinking water standard of 10 ppb
    - Providing outreach to health professionals, public and environmental health entities and other audiences

Public Health Action Plan

The Public Health Action Plan ensures that the health consultation identifies public health risks along with providing a plan of action designed to reduce and prevent adverse health effects from exposure to hazardous substances in the environment. This plan includes a description of actions that will be taken by EHAP in collaboration with other agencies to pursue the implementation of the recommendations outlined in this document.

Public Health Actions that have been implemented to date:

- EHAP contacted the 12 homeowners with arsenic detections above MCL by phone to notify them of their results, alert them of the health risks from using water with high arsenic concentrations, and to discuss options for reducing their exposure. These residents were sent their laboratory results, a fact sheet about arsenic in water, and local resources for bottled water, treatment and laboratory testing (Appendix C).
- DEQ collected confirmatory samples from the residences with arsenic detections above MCL and tested them for arsenic and other metals.
- EHAP notified all 105 study participants of their laboratory results by mail.
- EHAP issued a press release on the study's findings on August 4, 2008.
- EHAP held a public meeting in Sutherlin, OR on August 20, 2008. This was a general information session to answer questions and provide information about the study's findings, health effects from arsenic exposure, ways to reduce exposure, local resources for water/treatment systems, and general information about well safety and maintenance. Representatives from EHAP, the Environmental Public Health Tracking Program, the Douglas County Health Department, the Oregon DEQ, the Oregon State University Extension Services, and the Oregon Drinking Water Program were available to answer questions. Approximately 35 people attended the meeting.
- EHAP coordinated with the Douglas County Health Department to provide outreach about arsenic in wells to health care providers and other groups through a fax blast and an article in Douglas County's health newsletter (October 2008 issue of Health Matters).

Public Health Actions that will be implemented in the future:

- EHAP will release this document for public comment, and will incorporate these comments into the final version of this report.
- EHAP will coordinate with the Douglas County Health Department to conduct outreach to residents living in areas where high levels of arsenic in groundwater have been detected. This may include general outreach strategies (such as press releases or articles in local newspapers), or more targeted strategies such as direct mailings or door-to-door outreach.
- EHAP will be available to answer questions and provide information to Sutherlin Valley residents on the health effects associated with arsenic exposure, and recommendations and resources to reduce exposure through private wells.

Site Team

Oregon Office of Environmental Public Health

EHAP Team:

Author of Report
Sujata Joshi, MSPH
Epidemiologist

Karen Bishop, MPH
Public Health Educator

Julie Early-Alberts, MS
Program Coordinator

David Farrer, MS, PhD
Toxicologist

Jae P. Douglas, MSW, PhD
Principal Investigator

EPHT Team:

Mandy Green, MPH
Epidemiologist

Nancy Goff, MPH
Public Health Educator

Curtis Cude
EPHT Program Manager

Agency for Toxic Substances and Disease Registry:

Karen L. Larson, PhD
Regional Representative
Office of Regional Operations
ATSDR Region 10

Audra Henry
Technical Project Officer
Division of Health Assessment and Consultation
ATSDR

Certification

This Sutherlin Valley Groundwater Arsenic Study Health Consultation was prepared by the Oregon Department of Human Services under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodologies and a procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

Audra Henry
Technical Project Officer, DHAC, CAPEB
Agency for Toxic Substances & Disease Registry

The Division of Health Assessment and Consultation (DHAC) ATSDR, has reviewed this health consultation and concurs with the findings.

Alan W. Yarbrough
Team Lead, DHAC, CAPEB
Agency for Toxic Substances & Disease Registry

References

1. U.S. Geological Survey, *Arsenic in Ground-Water Resource of the United States*. 2000, U.S. Geological Survey,: Denver, CO.
2. Focazio, M., et al., *A retrospective analysis on the occurrence of arsenic in groundwater resources of the United States and limitations in drinking water supply charcterizations*, in *U.S. Geological Survey Water Resources Investigations Report* 1999, US Geological Survey.
3. Proehl, R.S., *2007 Oregon Population Report*, in *Oregon Population Report*. 2008, Population Research Center: Portland.
4. Oregon Labor Market Information System. *Overview of Douglas County.* 2007 [cited 2008 September 17]; Available from: http://www.qualityinfo.org/olmisj/Regions?page=1&area=000006.
5. U.S. Census Bureau. *QuickFacts for Douglas County, Oregon*. 2000 [cited 2008 September 17]; Available from: http://factfinder.census.gov.
6. Paterson, A. and C. Silvernale, *The Occurence of Arsenic in Well Waters of Douglas County, Oregon*.
7. Tester, M. and C. Silvernale, *The Occurence of Arsenic in Douglas County, Oregon*.
8. Oregon Drinking Water Program, *Oregon Drinking Water Program Data Online*. 2008, Oregon Department of Human Services.
9. Environmental Public Health Tracking Program. *Environmental Public Health Tracking Program*. 2008 [cited 2008 December 29]; Available from: http://www.oregon.gov/DHS/ph/epht/.
10. Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Arsenic (Update)*, Agency for Toxic Substances and Disease Registry, Editor. 2007: Atlanta, GA.
11. Environmental Protection Agency, *Issue Paper: Inorganic Arsenic Cancer Slope Factor*, Environmental Protection Agency, Editor. 2005.
12. Washington State Department of Health, *Evaluation of Soil Contamination, Apple Valley Elementary School*. 2006: Olympia, WA.
13. Navas-Acien, A., et al., *Arsenic Exposure and prevalence of Type 2 Diabetes in US Adults.* Journal of the American Medical Association, 2008. **300**(7): p. 814-822.

Appendix A: General Information about Arsenic

Arsenic is a naturally-occurring element, and can be found in water, air and land. Most people are exposed to low levels of arsenic on a daily basis through food, water and air. In the U.S., the average person takes in 50 micrograms of arsenic a day. The main source of arsenic in the diet is seafood. Most of the arsenic found in seafood is organic arsenic, which is much less toxic than inorganic arsenic. The main dietary sources of inorganic arsenic in the U.S. are grains, produce, and meat. The other major sources of arsenic exposure in the U.S. are through drinking water, exposure to arsenic in soils and consumer products (such as some types of treated wood), and occupational exposures. While most people do not come into contact with harmful levels of arsenic, some people can be exposed to levels that can cause serious health effects. The best way to reduce the risk for any health effects from arsenic exposure is to limit or stop any exposures to arsenic.

Inorganic arsenic is highly toxic and has been shown to affect most of the major organs and systems in the human body. Swallowing very large amounts of arsenic (over 60,000 ppb) can cause death, but these levels of exposure rarely occur in the U.S. People who are exposed to high levels of arsenic can quickly experience noticeable symptoms, including stomach irritation with symptoms of nausea, vomiting, diarrhea and pain; fatigue caused by decreased blood cell production; abnormal heart rhythms; and a "pins and needle" sensation in the hands and feet, which is caused by nerve damage [10]. Some of these symptoms will improve if a person is able to reduce or stop their exposure to arsenic.

People who are exposed to lower levels of arsenic may not immediately notice symptoms, but over time can experience serious health effects. One of the most noticeable symptoms is changes in the skin, which can take the form of dark patches, lesions on the hands, feet and torso, and areas of thickened skin. There can also be damage to the cardiovascular system which can result in circulatory problems and high blood pressure. Long-term, low-level exposure to arsenic can result in decreased production of white and red blood cells, which results in anemia and decreased immune function. A recent study has found an association between long-term exposure to arsenic and type 2 diabetes[13].

Arsenic is a known carcinogen, meaning it can increase the risk for developing several types of cancer. Exposure to inorganic arsenic has been found to increase the risk for cancers of the skin, lung, bladder, kidney, liver and prostate. A person's risk for developing cancer depends on how much arsenic a person is exposed to, how long a person is exposed, and factors such as diet, smoking, occupational exposures and other lifestyle factors.

There are some tests that can show if a person has been exposed to higher-than-normal levels of inorganic arsenic; however, these tests have some limitations. Most inorganic arsenic will leave the body through the urine over the course of several days, though a

small amount can stay in the body for several months. Urine tests can show if a person has recently been exposed to arsenic. However, these tests can show high results if a person has recently eaten seafood that contains high levels of organic arsenic (which is not believed to cause harmful health effects). Hair and nail tests can show if a person was exposed to high levels of arsenic up to one year in the past. However, none of these tests can provide information on how much a person has been exposed to, or whether a person will develop health effects from their exposure.

Appendix B: Equations and Exposure Assumptions used in Dose Calculations

1. Exposure from Domestic Wells

$$\text{Non-Cancer Dose} = \frac{Cw \times CF1 \times IRW \times EF \times ED}{BW \times AT_{nonc}}$$

$$\text{Cancer Dose} = \frac{Cw \times CF1 \times IRW \times EF \times ED}{BW \times AT_{c}}$$

2. Exposure from Irrigation Wells

$$\text{Non-Cancer Dose} = \frac{Cw \times CF1 \times IRWi \times RT \times EFi \times EDi}{BW \times AT_{nonc} \times CF2}$$

$$\text{Cancer Dose} = \frac{Cw \times CF1 \times IRWi \times RT \times EFi \times EDi}{BW \times AT_{c} \times CF2}$$

3. Cancer Risk = Cancer Dose x Cancer Slope Factor

Table B.1: Exposure assumptions used in calculating child and adult exposure doses.

Parameter	Value		Units	Notes
	Child (Less Than 6)	Adult		
Chemical Concentration in Water (Cw)	chemical specific		µg/L = ppb	Concentrations measured during study
Conversion Factor (CF1)	0.001		mg/µg	Converts contaminant concentration from micrograms to milligrams
Ingestion Rate Water (IRW)	1.5	2.3	L/day	DEQ Deterministic HHRA Guidance, Appendix B
Exposure Frequency (EF)	350	350	days/year	DEQ Deterministic HHRA Guidance, Appendix B; Away for 2 weeks per year
Exposure Duration (ED)	6	30	years	DEQ Deterministic HHRA Guidance, Appendix B; Assuming average time at residence = 30 years
Body Weight (BW)	15	70	kg	EPA Exp Factors Handbook
Averaging Time - Noncancer (AT_{nonc})	2190	10950	Days	DEQ Deterministic HHRA Guidance, Appendix B - Child and Adult
Averaging Time - Cancer (AT_c)	25550		Days	DEQ Deterministic HHRA Guidance, Appendix B - Child and Adult; 70 years
Incidental Ingestion Rate Water (IRWi)	0.1	0.07	L/day	Professional judgment
Recreation Time - Incidental Ingestion (RT)	1	1	Hr/day	Assume 1 hour/day
Exposure Frequency - Incidental Ingestion (EFi)	60	120	Days/year	Professional judgment
Exposure Duration - Incidental Ingestion (EDi)	6	30	Years	DEQ Deterministic HHRA Guidance, Appendix B; Assuming average time at residence = 30 years
Conversion Factor (CF2)	24		Hours/day	Converts hours into days

Appendix C: Community Resources for Sutherlin Valley Arsenic Study

Water Resources for People living in the Sutherlin, Yoncalla, Oakland, and Nonpareil areas:

Crystal Falls
4390 Douglas Street
Roseburg, OR 97470
(541) 672-0799

They do deliver east of Nonpareil.
Cost: $5.75 for 5 gallons; $4.00 for 3 gallons
They provide several dispenser options either for rent or to purchase
Costs of renting dispensers run from $2/ month to $12/month.

Umpqua Aqua
4850 NE Stephens St
Roseburg, OR 97470
(541) 672-7873

They do not deliver – this is self-service only
They treat Umpqua river water with reverse osmosis and ultraviolet light.
They sell bottles for water: $11 for a 5 gallon bottle, with one free fill up; they also have a variety of dispensers to purchase
Cost: $1.00 for 5 gallons and .25 cents a gallon thereafter
Hours: 8am-8pm everyday

Coca Cola Bottling Company of Roseburg
612 NW Cecil Ave
Roseburg, OR
(541) 672-6596

They deliver out in that area, but may not for much longer
Cost: $6.50 or 5 gallons, plus a $1.50 delivery fee. Water stands rent for $8/month

---

Reverse Osmosis Water Filtration Systems:

Dealer Culligan Water Systems
12 West Q Street unit D
Springfield, OR 97477
Phone 541-484-0343
FAX 541-736-7524
Email dlqualitywater@aol.com

They provide a basic, installed drinking water system for $825.00
However, the cost and type of system depends upon several factors, including acidity level, silica content, hardness and levels of arsenic. Call for a consultation. **They also provide delivery of bottled water in this area for $6.50 for 5 gallons.**

Certified private well testing labs in the area:

- **Umpqua Research Company – Myrtle Creek**
  626 NE Division, PO Box 609
  Myrtle Creek, OR 97457
  (541) 863-5201

Procedure & Cost:
Packets (3 bottles) can be picked up at Sutherlin City Hall for free. One bottle is for bacteria, one for nitrates or some other test, and one for arsenic (or other metal), although you can choose to have only one test. The breakdown for each is as follows:

Tests: Arsenic $32
Bacteria: $38
Nitrate: $45

They also have a package that includes many more tests – for $200. All samples must be delivered to the lab within 24 hours – on ice. Hours are 8:30-5:00 M-F. They don't accept nitrates after 2:00pm on Fridays.

- **Analytical Laboratory & Consultants, Inc**
  361 West 5th Ave
  Eugene, OR 97754
  (541) 447-4911

Procedure & Cost:
Either pick up correct bottles from their office, or have them ship them to your home for $10. Along with the sampling bottles, you will get a form and instructions. 3-4 working days turn-around time.

Tests: Arsenic - $25
Bacteria - $32
Nitrates - $32

Or for $100 – all of the above plus tests for hardness, iron, pH, and conductivity

---

- **Delta Environmental Services, Inc**
  36 Irving Rd
  Eugene, OR 97404
  (541) 689-3177

Procedure & Cost:
Same as above, but they are willing to ship the bottles in a cooler intended for a return mailing if testing will include bacteria and nitrates, which need to be kept a 6 degrees Celsius or less.

Tests: Arsenic: $25
Bacteria: $27
Nitrates: $24

Or $95 for all 3 and also includes tests for hardness, iron, pH, conductivity, and turbidity

---

Link to list of certified labs
http://oregon.gov/DHS/ph/orelap/docs/acclab.pdf

ARSENIC IN WELL WATER

Frequently Asked Questions

What is arsenic and where does it come from?
Arsenic is a naturally occurring element in the earth's crust. As water flows through certain rock formations, it can dissolve arsenic and carry it into underground aquifers, streams or rivers that may be used as drinking water sources.

What is the maximum contaminant level for arsenic in drinking water?
Arsenic is measured in parts per billion (ppb). The current drinking water standard for arsenic is 10 ppb. Because arsenic is a health hazard, OPH recommends switching to bottled water if your well water level is above 10 ppb.

How can arsenic affect my health?
Drinking water contaminated with high levels of arsenic puts your health at risk. Health effects may include:

- Thickening and discoloration of the skin, stomach pain, nausea, vomiting, and diarrhea.
- Heart, lung, liver, immune, nervous, or reproductive system disorders and diabetes.
- Cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate.

Children are especially susceptible to the effects of arsenic due to their smaller size, and developing bodies and brains.

Should I boil my water if it has high levels of arsenic?
No. Boiling water can concentrate levels of arsenic. Boiling water does not remove arsenic.

Can I remove arsenic from my drinking water?
Yes. Several treatment methods can remove arsenic from drinking water. The most common treatment method used is called a reverse osmosis filtration system. Any system you select should be certified by a recognized, third-party testing organization that meets strict testing protocols established by the American National Standards Institute (ANSI) and NSF International.

Keep in mind that filters may not be effective in all cases. We recommend you continue testing your water on a yearly basis, and that any filtration equipment be well maintained to ensure proper functioning.

DHS | Independent. Healthy. Safe.

Can I wash my food with my well water?
We recommend that bottled water be used to wash, prepare and cook food if your water contains levels of arsenic above 10 ppb.

What about bathing and showering?
Bathing, swimming and showering with water that has levels as high as 500 ppb is safe as long as swallowing the water is avoided as much as possible. Arsenic doesn't readily enter the body through the skin. Keep in mind that small children will need supervision when bathing and brushing teeth in order to avoid swallowing the water.

Washing dishes, utensils, and food preparation areas:
Only very small amounts of water clings to smooth, nonporous surfaces, like dishes. You can safely use water having up to 500 ppb of arsenic to wash and sanitize dishes, tables and eating utensils.

General cleaning and laundry:
Very little water remains on washed surfaces and in laundered fabrics. Since these articles are not placed in the mouth, water having up to 500 ppb of arsenic may be safely used for general cleaning and washing of clothing, bedding and linens.

What about my pets?
Animals should not drink water that is above 10 ppb.

Where can I go to get my water tested?
Accredited laboratories throughout the state provide well water testing for private well owners. These labs can give you the information and instructions you need to have your well water tested. For a list of accredited laboratories in Oregon, call the Department of Human Services Laboratory Accreditation Program at 503-693-4122 or visit: http://oregon.gov/DHS/ph/orelap/docs/acclab.pdf.

For more information:
For questions and concerns about arsenic in your well, please contact Sujata Joshi at 971-673-1213, or by email at sujata.joshi@state.or.us

Appendix D. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR serves the public by using the best science to take responsive public health actions and provides trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption:	How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.
Acute Exposure:	Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.
Additive Effect:	A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.
ATSDR:	The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.
Background Level:	An average or expected amount of a chemical in a specific environment, or amounts of chemicals that occur naturally in a specific environment.
Bioavailability:	See **Relative Bioavailability**.
Cancer:	A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control
Carcinogen:	Any substance shown to cause tumors or cancer in experimental studies.
CERCLA:	See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.
Chronic Exposure:	A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.
Completed Exposure Pathway:	See **Exposure Pathway**.

Comparison Value (CVs):	Concentrations of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA):	**CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. This act created ATSDR and gave it the responsibility to look into health issues related to hazardous waste sites.
Concern:	A belief or worry that chemicals in the environment might cause harm to people.
Concentration:	How much or the amount of a substance present in a certain amount of soil, water, air, or food.
Contaminant:	See **Environmental Contaminant**.
Delayed Health Effect:	A disease or injury that happens as a result of exposures that may have occurred far in the past.
Dermal Contact:	A chemical getting onto your skin. (see **Route of Exposure**).
Dose:	The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day".
Dose / Response:	The relationship between the amount of exposure (dose) and the change in body function or health that result.
Duration:	The amount of time (days, months, years) that a person is exposed to a chemical.
Environmental Contaminant:	A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than the **Background Level**, or what would be expected.
Environmental Media:	Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.
U.S. Environmental Protection Agency (EPA):	The federal agency that develops and enforces environmental laws to protect the environment and the public's health.
Epidemiology:	The study of the different factors that determine how often, in how many people, and in which people will disease occur.

Exposure: Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see **Route of Exposure**.)

Exposure Assessment: The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway: A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:
1. Source of Contamination,
2. Environmental Media and Transport Mechanism,
3. Point of Exposure,
4. Route of Exposure, and
5. Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Frequency: How often a person is exposed to a chemical over time; for example, every day, once a week, twice a month.

Hazardous Waste: Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effect: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Indeterminate Public Health Hazard: The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

LOAEL: **L**owest **O**bserved **A**dverse **E**ffect **L**evel. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

MRL: **M**inimal **R**isk **L**evel. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

NPL:	The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.
NOAEL:	**N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.
No Apparent Public Health Hazard:	The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.
No Public Health Hazard:	The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.
PHA:	**P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.
Point of Exposure:	The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). Some examples include: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, or the backyard area where someone might breathe contaminated air.
Population:	A group of people living in a certain area; or the number of people in a certain area.
PRP:	**P**otentially **R**esponsible **P**arty. A company, government or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of a site.
Public Health Assessment(s):	See **PHA**.
Public Health Hazard:	The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each is defined in the Glossary. The categories are:
– Urgent Public Health Hazard
– Public Health Hazard
– Indeterminate Public Health Hazard
– No Apparent Public Health Hazard
– No Public Health Hazard

Reference Dose (RfD): An estimate, with safety factors (see **safety factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is not likely to cause harm to the person.

Relative Bioavailability: The amount of a compound that can be absorbed from a particular medium (such as soil) compared to the amount absorbed from a reference material (such as water). Expressed in percentage form.

Route of Exposure: The way a chemical can get into a person's body. There are three exposure routes:
– breathing (also called inhalation),
– eating or drinking (also called ingestion), and
– getting something on the skin (also called dermal contact).

Safety Factor: Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

SARA: The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects resulting from chemical exposures at hazardous waste sites.

Sample Size: The number of people that are needed for a health study.

Sample: A small number of people chosen from a larger population (See **Population**).

Source (of Contamination): The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

Special Populations: People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Statistics: A branch of the math process of collecting, looking at, and summarizing data or information.

Superfund Site: See **NPL**.

Survey:	A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.
Toxic:	Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.
Toxicology:	The study of the harmful effects of chemicals on humans or animals.
Tumor:	Abnormal growth of tissue or cells that have formed a lump or mass.
Uncertainty Factor:	See **Safety Factor**.
Urgent Public Health Hazard:	This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.