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Public Health Division
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Health Consultation

Crook County Wells – Draft for Public Comment

Acknowledgments

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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. To prevent or mitigate exposures, a consultation may recommend specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

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.

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Introduction

Through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), the Oregon Health Authority (OHA) Public Health Division's (PHD) Environmental Health Assessment Program (EHAP) works to ensure that a community around the site of a possible environmental hazard has the best information possible to protect its health. The goal of this report is to provide information to the community to make informed health-based decisions. EHAP evaluates people's exposures to hazardous substances in the environment and determines whether these exposures pose a health risk. We make recommendations to eliminate or reduce exposures.

EHAP has been involved with public health related work at this site since late 2023 when Crook County Commissioners convened a group of state agency representatives to address groundwater quality issues raised by their constituents. EHAP was included in this group and collaborated with other state agencies and the local health department to plan a response. EHAP worked with Crook County Health Department, the Oregon Departments of Environmental Quality (DEQ) and Geology and Mineral Industries (DOGAMI), and individual community members to collect information about community health concerns and sampling data from local domestic wells located in Crook County, Oregon.

DEQ hired an environmental contractor to sample 55 Crook County wells in November 2024, and 58 wells in Spring 2025. Fifty-two of the Spring 2025 sample sites were also sampled in 2024. DEQ shared sampling results and EHAP provided individual consultations to well owners that were interested in receiving support interpreting their sampling results. DEQ published the results of well sampling in July 2025. The full sampling report is available online. The levels of contaminants in the groundwater samples indicate that some well water in the area can pose health risks to people of certain ages who drink the water for varying amounts of time.

Conclusions and next steps

Conclusions and recommendations are organized by contaminant. Contaminants are listed alphabetically with the more concerning conclusions presented at the beginning of a contaminant section. There are 13 conclusions overall, and conclusion numbering continues from contaminant to contaminant (i.e., numbering does not start over with each contaminant).

The results in this section and throughout the report for nearly all contaminants are expressed as micrograms per liter of water (µg/L). One µg/L is equivalent to one drop of water in an Olympic-size swimming pool. Nitrate is expressed as milligrams per liter (mg/L) of water, equivalent to a pinch of salt in a large trash can of water. This is because nitrate has health effects only when present at much higher levels than the other contaminants discussed in this report and expressing the level as micrograms per liter would result in very large numbers that are harder to read and understand.

Arsenic	EHAP reached 3 conclusions about arsenic
Conclusion 1	Children under 1 year-old who drink water from wells with arsenic levels over 35 µg/L for one day or more are at risk of facial swelling, nausea, vomiting, and diarrhea.
Basis for conclusion	One well in the study had arsenic concentrations above 35 µg/L. Well water containing arsenic over 35 µg/L poses an acute risk to infants under 1 year-old who drink it, even for just a short time, as in a day or more. Formula-fed infants are at highest risk because they get the highest dose of arsenic.
Conclusion 2	Anyone who drinks water from wells with arsenic levels over 2 µg/L for a year or more is at increased risk of cancers of the skin, bladder, and lungs, as well as wart-like lesions and changes in the blood vessels of the skin.
Basis for conclusion	In this well study, 51 out of 55 wells in the Fall of 2024 and 55 out of 58 wells in the Spring of 2025 had water with arsenic levels over 2 µg/L. While this concentration is below the public drinking water standard for arsenic (10 µg/L), it is high enough to increase cancer risk and increase the risk of non-cancer health effects of the skin if it is the primary drinking water source for a year or more. At the highest levels of arsenic measured in the study (38.6 µg/L), a person drinking it for a year or more is also at risk of more non-cancer health effects. Arsenic is a very common, naturally occurring contaminant in groundwater wells in Oregon.
Conclusion 3	Drinking well water with 2 µg/L or less of arsenic poses very low risk to anyone.
Basis for conclusion	Four wells had arsenic below 2 µg/L in the Fall of 2024 and three wells had arsenic below 2 µg/L in the Spring of 2025 in this study. Arsenic at or below 2 µg/L in well water is too low to harm the health of anyone who drinks it.
Next steps	

	EHAP recommends that: - All well users test their wells every 3 to 5 years for arsenic to monitor levels over time and after major events such as flooding or earthquakes. - Well users with more than 35 µg/L arsenic immediately find a safer alternative source of water for children under 1 year-old to consume, including for use in formula, because a short-term exposure at or above this level can cause acute risk to children under this age. - Well users with more than 2 µg/L of arsenic in their wells ensure treatment is in place or find an alternate source of water to drink, prepare beverages, and cook food to reduce the risk to health from long-term exposure. EHAP will: - Remain available to consult with community members about health risks related to their individual well testing results. - Continue to provide information about well testing and where to learn more about treatment options.

Copper	EHAP reached 2 conclusions about copper
Conclusion 4	Children under 1 year-old who drink well water with copper levels over 140 µg/L for 1 day or more are at increased risk of abdominal pain, nausea and vomiting.
Basis for conclusion	One well in the study had copper levels over 140 µg/L. Copper is an essential nutrient, but at 140 µg/L in well water there is enough to cause acute symptoms in a child under 1 year-old, since that is the age group that would get the highest dose. High levels of copper in the short-term can irritate the lining of

	the digestive tract causing abdominal pain, nausea, and vomiting. Children older than 1 and adults are not at risk from any of the levels of copper measured in the study. Copper in drinking water is often the result of leaching from piping or plumbing fixtures.
Conclusion 5	Drinking well water with copper levels at or below 140 µg/L is not expected to harm anyone's health.
Basis for conclusion	Copper at or under 140 µg/L in water is too low to harm the health of anyone who drinks it. Children older than 1 year and adults are not at risk from any of the levels of copper measured in the study.
Next steps	
	EHAP recommends that: • Anyone with copper levels over 140 µg/L in their well water immediately find a safer, alternate source of water for children under 1 year-old to consume, including for use in infant formula. • Anyone with copper levels over 140 µg/L in their well water confirm the test results and, if confirmed, seek treatment and evaluate whether copper in plumbing or plumbing fixtures is the source. EHAP will: • Remain available to consult with community members about health risks related to their individual well testing results. • Continue to provide information about well testing and where to learn more about treatment options.

Fluoride	EHAP reached 1 conclusion about fluoride
Conclusion 6	Fluoride levels in the wells tested in this study were too low to harm the health of anyone who drinks it.
Basis of conclusion	The levels of fluoride measured in this study (maximum of 1,250 µg/L) were not high enough to harm health.

Lead	EHAP reached 1 conclusion about lead
Conclusion 7	Test results showed elevated lead in some wells. People who drink water from wells containing detectable levels of lead for any amount of time are at increased risk of health effects. Children are at greatest risk because they get the highest dose of lead from the water and because their brains are in developmental stages that are sensitive to changes caused by lead.
Basis of conclusion	There is no safe level of lead. In this well study, 26 wells had detectable levels of lead. The health effects associated with the lowest doses of lead are impaired brain development in people exposed as children leading to decreases in IQ and increases in the potential for neurobehavioral problems. These problems may persist long after the exposure to lead has ended. The most common sources of lead in drinking water are plumbing, plumbing fixtures, and old well components.
Next steps	
	EHAP recommends that people whose wells have detectable levels of lead: • Seek blood lead testing for all household members, especially children, from their own healthcare providers.

	• Do additional water testing to determine whether the source of lead is the well itself or plumbing. • Run water long enough to flush out water that has been standing in lead-containing plumbing (usually 1-2 minutes) before collecting water to drink or use in beverages or cooking. • Consider replacing lead-containing plumbing, plumbing fixtures, or well components, especially if flushing is not effective at bringing down lead levels in tap water. EHAP will: • Provide information about how to get blood lead levels tested. • Remain available to consult with community members about health risks related to their individual well testing results. • Continue to provide information about well testing and where to learn more about ways to reduce lead exposure.

Manganese	**EHAP reached 2 conclusions about manganese**
Conclusion 8	Children under 1 year of age who drink well water containing over 300 µg/L manganese for a year are at increased risk of neurobehavioral and cognitive problems.
Basis for conclusion	Seven wells in this study had manganese levels over 300 µg/L. Manganese is an essential nutrient, but water with more than 300 µg/L can be too much for children under 1 year-old, which is the group that would get the highest dose from water. Children older than 1 year and adults are not at risk from manganese in drinking water even at the highest concentration measured in the study (464 µg/L).

Conclusion 9	Water with manganese levels over 50 µg/L may be unpleasant to use and drink for people of all ages.
Basis for conclusion	Starting at 50 µg/L, manganese can cause black sedimentation, stain laundry, appear cloudy, and taste metallic and unpleasant. Water with levels between 50 and 300 µg/L manganese does not pose health risks to anyone but it is likely to be unpleasant to use for these aesthetic reasons. In this study, 27 wells had manganese levels between 50 and 300 µg/L.
Next steps	
	EHAP recommends that people with manganese levels over 300 µg/L in their well water: • Ensure that treatment is in place or that an alternate source of water is available for children under 1 year-old to drink, including for use in infant formula. EHAP recommends that people with manganese levels between 50 and 300 µg/L in their well water: • Consider seeking treatment options to address aesthetic problems. EHAP will: • Remain available to consult with community members about health risks related to their individual well testing results. • Continue to provide information about well testing and treatment resources.

Nitrate	EHAP reached 2 conclusions about nitrate
Conclusion 10	Children under 6 years old who drink water with nitrate at 10 or more milligrams per liter (mg/L) for a day or more are at increased risk of methemoglobinemia, or blue-baby syndrome, which is reduced oxygen-carrying capacity of red blood cells. Women in the third trimester of pregnancy who drink water with 10 mg/L or more of nitrate may also be at increased risk of miscarriage. Anyone who drinks water with 10 mg/L or more of nitrate for 1 year or more may also be at increased risk of stomach cancer and thyroid problems.
Basis for conclusion	Twelve wells in this study had nitrate over 10 mg/L. Nitrate over 10 mg/L in drinking water can decrease the capacity of red blood cells to carry oxygen throughout the body. Formula-fed infants are at highest risk because they get the highest dose of nitrate from drinking water. Formula-fed infants are also at highest risk because methemoglobinemia (blue-baby syndrome) can become acutely life threatening for them. Children 6 years and older and non-pregnant women are at much less risk from short-term exposures, but all ages may have increased risk of cancer and thyroid problems if they drink water with 10 mg/L or more of nitrate for a year or more.
Conclusion 11	Well water with nitrate between 5 and 10 mg/L does not pose health risks but is at risk of fluctuating above 10 mg/L at different times of year. In addition, boiling water during cooking, or for preparation of hot drinks, can increase (worsen) the nitrate concentration and increase the health risk.
Basis for conclusion	This study found 13 wells with nitrate between 5 and 10 mg/L. Nitrate levels in this range in well water are too low to harm health, but above naturally-occurring levels, indicating that nitrate is entering the well from a local source. The most common sources are nearby livestock or other agricultural practices or failing septic systems. These inputs can change seasonally with different water table levels and surface runoff

	conditions. This means that nitrate levels between 5 and 10 mg/L in well water can fluctuate seasonally posing a risk that the well may have nitrate at or over 10 mg/L during some parts of the year or increase over the course of multiple years.
Next steps	
	EHAP recommends that everyone who uses a private domestic well for drinking water: • Test their well at least annually for nitrate. EHAP recommends that people with well water containing 10 mg/L or more of nitrate: • Ensure that treatment is in place or immediately provide a safer alternative source of water for children under 6 years-old and women in the third trimester of pregnancy to drink, use in beverages, or cook. • Ensure treatment is in place or find a safer alternative source of water for all members of the household to use for drinking, making beverages, and cooking food over the long-term. • Identify and reduce or eliminate local sources of nitrate (e.g., nearby agriculture, livestock, or failing septic systems) and try to reduce nitrate infiltration into their well, including checking surface seals around the well to ensure seepage is not occurring along the well casing. EHAP recommends that people with well water containing between 5 and 10 mg/L nitrate: • Test their well water more frequently at different seasons of the year, particularly summer, to make sure nitrate is staying below 10 mg/L all year. • Consider looking for local sources of nitrate (e.g., nearby agriculture, livestock, or failing septic systems) and ways to reduce their infiltration into their well, including

	checking surface seals around the well to ensure seepage is not occurring along the well casing. EHAP will: • Remain available to consult with community members about health risks related to their individual well testing results. • Continue to provide information about well testing and treatment resources.

Total coliform	EHAP reached 2 conclusions about total coliform
Conclusion 12	People who drink water from wells with detectable levels of total coliform for any amount of time are at increased risk of gastrointestinal symptoms like abdominal pain, nausea, vomiting, and diarrhea. Infants, young children, and people with compromised immune systems are at greatest risk.
Basis for conclusion	In Fall of 2024, 13 wells in this study tested positive for total coliform. In Spring of 2025, only 4 wells tested positive for total coliform. Total coliform is a broad category of bacteria, and not all of them cause disease (are pathogenic). The laboratory retested samples from all wells that tested positive for total coliform to look for a specific pathogenic species of bacteria in the total coliform category called *Escherichia coli* (E. coli). None of the wells tested positive for E. coli, but finding total coliform indicates that bacteria are getting into some wells, and some of those could include illness-causing bacteria or E. coli in the future. The source of total coliform in well water is usually a break in the well seal, impacts from a septic system, or animals and/or animal waste near the well head.
Next steps	
	EHAP recommends that everyone who uses a private domestic well for drinking water:

	• Test their well at least annually for total coliform and conduct follow up testing for E. coli if total coliform are found. EHAP recommends that anyone whose well tested positive for total coliform: • Follow guidance available at and referenced by OHA's Domestic Well Safety Program's Well User Resource Toolkit (available at www.healthoregon.org/wells) to identify potential sources of bacterial contamination and disinfect the well. • Test again after disinfecting the well to make sure efforts to eliminate total coliform were successful. EHAP will: • Remain available to consult with community members about health risks related to their individual well testing results. • Continue to provide information about well testing and treatment resources.

Vanadium	EHAP reached 1 conclusion about vanadium
Conclusion 13	Vanadium levels in the wells tested in this study were too low to harm the health of anyone who drinks it.
Basis of conclusion	Vanadium is a metal that can increase blood pressure and cause other problems with the blood. The levels of vanadium measured in this study (maximum of 73.2 µg/L) were not high enough to harm health.

Background

A number of residents in rural areas near the community of Prineville, Oregon (Crook County) raised concerns about contaminants in their domestic well water. These include concerns about human health, animal health, fouled plumbing and appliances, and the odor, taste, and appearance of well water. Local and state officials contacted the OHA to ask whether EHAP could help answer community questions about possible health risks from using the water for drinking, cooking, bathing, and other daily uses.

To assess whether the well water in this area poses a risk to human health, EHAP needed to know what harmful chemicals may have been in the water and in what amounts. EHAP relies on data from environmental testing laboratories and environmental agencies like the DEQ or U.S. Environmental Protection Agency (EPA). Those organizations produce data about what is in the environment, and EHAP evaluates the data to understand what it means for public health. DEQ was able to obtain funding to carry out testing of certain Crook County domestic wells in 2024 and 2025 and designed a sampling plan in consultation with OHA, other state agencies, and Crook County Commission and staff.

EHAP administered an in-person and online survey to gather information about community sampling needs. The survey included questions about how domestic well water is used in local households, the types of health concerns that well users experienced, and other resources that well owners were interested in.

Natural resources and land use

All domestic well sampling locations are located within Crook County, Oregon, and outside of the city limits of Prineville, Oregon. The sampling area is primarily zoned for Exclusive Farm Use and Rural Residential, with some parcels designated for Light and Heavy Industrial Use. (1) Within the sampling area are several irrigation canals, creeks, small farms, and industrial facilities.

Community demographics

Crook County is located in Central Oregon and is 2,978.9 square miles. As of 2020, the population of Crook County was 24,738 people. (2) 25.1% of the County's population is 65 years and older, as compared to Oregon's rate of 19.6%. Of Crook County residents, 84.4% are White, 7.3% are Hispanic or Latino, 6.0%

are two or more races, and 1.1% are American Indian or Alaska Native. 90.0% of Crook County residents are high school graduates, while 19.8% are college graduates. (3)

EHAP's community outreach and education activities

An important part of environmental public health assessment activities is the collection, documentation, and response to community health and exposure concerns and sharing important health information back to community to prevent harmful exposures. To facilitate this process, EHAP cosponsored with the Crook County Commission and county health department a Crook County Domestic Well Safety Open House and Information Gathering event at the Prineville Public Library on May 30, 2024. While the focus of the event was to hear from community members about health concerns related to their consumption and use of domestic well water, DEQ and the Oregon Department of Agriculture (ODA) also attended to answer residents' questions. EHAP created community resources for the event and is providing ongoing support, including:

- A dedicated website at Oregon.gov/CrookCoWells
- An event flyer
- A 10-minute YouTube video that played at the May 30 meeting and remains an online source of information about Health Consultations
- A questionnaire in online and paper versions to ask about health concerns and request a consultation with an OHA toxicologist

EHAP used responses from the community survey to inform DEQ's sampling plan for the area. DEQ's contractor sampled 55 domestic wells in the community during November 2024. DEQ's contractors tested samples for 43 different chemicals, called "analytes." The primary focus of the sampling was metals. However, DEQ's contractor also tested for total coliform (bacteria), nitrate, anions, cations, and other general water quality parameters.

Since total coliform was detected in several of the wells and bacteria in well water can be treated readily, EHAP notified households that tested positive for total coliform by sending emails or letters in November 2024. This notification included information about recommended next steps and resources to address this problem. While total coliform in well water does not necessarily mean that people drinking the water will get sick, coliform presence does indicate that germs are getting into the well somehow. At any time, some of those germs entering the well could be pathogenic (disease-causing). The health effects associated with pathogenic bacteria in well water are gastrointestinal with symptoms like stomach cramping, diarrhea, nausea, and vomiting.

In January 2025 EHAP received the full laboratory results and shared each household's results with the residents living there. In the same communication, EHAP included health information about the metals and other contaminants that were detected and informational resources about treatment. EHAP offered each household the opportunity to speak an OHA toxicologist about the results of their well water test.

DEQ's contractors sampled 58 domestic wells in the community during April and May 2025, 52 of which were repeat samples of wells tested in 2024. Again, the primary focus of the sampling was metals, although DEQ's contractors also tested for total coliform (bacteria), nitrate and other analytes as in 2024.

In June 2025 EHAP received the results of the second round of water sampling DEQ conducted in April and May 2025 and finished sending the results out to individual well users in early July. EHAP again included health information about the metals any other analytes detected and information about treatment options along with the full laboratory results. OHA again offered individual consultations with a toxicologist to all recipient households.

Community Concerns

Understanding and addressing community concerns related to environmental health is an essential part of the Health Consultation process. Crook County community members, including domestic well owners, shared a variety of concerns related to domestic well water quality in the area. These concerns are summarized by themes below. When an explanation is similar for certain concerns, EHAP has provided a combined response. Concerns fell into two major themes: 1) Concerns related to health problems, and 2) Concerns that are outside of the Health

Consultation scope. EHAP's responses to these themes and specific concerns are listed below:

Concerns related to human health

Community members shared experiences and concerns related to health problems they or their families experienced after consuming or coming into contact with domestic well water. Health problems that community members shared include gastrointestinal problems and excessively dry, itchy skin and resulting skin lesions.

Response: EHAP recognizes that exposure to high levels of well contaminants presents serious health risks, depending on the contaminant, length of exposure and age of the person consuming the groundwater. This Health Consultation demonstrates that there are serious health risks associated with drinking water from wells with elevated levels of contaminants.

To alert residents to potentially harmful exposures to contaminants in domestic well water, EHAP offered individual consultation to all well owners in the area, including assistance interpreting individual well sampling results and recommending next steps. Households with increased health risks due to contaminants in their wells have received information about steps to take to prevent harmful exposures. EHAP is available to provide further consultation to any well owners in the area upon request.

In general, the best way to avoid harmful health effects is to follow the recommended exposure prevention steps discussed in the Recommendations section of this report, including testing your domestic well at least yearly for nitrate and total coliform and every 3 to 5 years for arsenic and other metals of concern.

Concerns that are outside of the Health Consultation scope

A Health Consultation is a highly technical report that uses quantitative environmental data sampled from the site and existing toxicological information about the contaminants in the groundwater to determine if it could harm the health of people who use it. Although Health Consultations do include information about community concerns, EHAP is only able to address community concerns that relate to the following:

- Community concerns including potential exposure and health effects expressed by the community.

- Actions EHAP has taken to learn about the community's health concerns.
- How community health concerns may relate to contaminants identified through environmental testing, and how people may have been exposed (i.e., "exposure pathways").

Some community concerns are not within the scope of issues or questions EHAP can address. However, these concerns are important to document in order to help other agencies and organizations understand the impact of the site on the affected community.

Mitigation costs

The community shared financial hardships related to installing expensive filtration systems for their homes and outbuildings. Some residents have had to replace costly appliances and re-install new filtration systems multiple times due to poor water quality. Other community members have spent time and financial resources both bringing bottled water into their homes and traveling to access clean water elsewhere.

Response: Although this is out of the scope of the Health Consultation, EHAP is grateful for the opportunity to highlight this community concern. EHAP acknowledges that accessing safe water is critical for health and that installation of treatment systems can be costly. Generally, private well owners are responsible for well maintenance, treatment, and routine well water testing to be sure the water is safe to drink. In cases where there is a clear source of contamination caused by a responsible party; the responsible party assumes the costs of mitigation. In this case, the state has not identified a responsible party and EHAP does not have the jurisdiction or expertise to determine responsibility.

Animal health concerns

Community members expressed concerns related to the health of livestock and other domestic animals. Multiple households reported instances of cattle deaths and calf stillbirths that they attributed to consumption of domestic well water.

Response: This Health Consultation focuses on risks to human health. The impact on animal health is assessed by different agencies and processes. ODA recommends consulting with your veterinarian regarding animal health concerns.

For household pets, ODA suggests consulting with a veterinarian or erring on the side of providing the same drinking water used for people.

Potential sources of domestic well contamination

Community members shared concerns related to potential sources of the domestic well contaminants, including a local mine operated by Knife River Corporation. Community members shared beliefs that domestic well water problems are attributable to the company's local gravel pit mine, located at 4755 NW Stahancyk Lane, in Prineville, OR. Residents in the area cite distinct changes in their domestic well water quality after the company obtained a gravel mining permit in 2017. The company both extracts gravel and operates holding ponds used in the process of washing excavated material and rocks transported from offsite. Residents explained that holding ponds are unlined and discharge directly into the aquifer that is up-gradient from numerous domestic wells in the area.

Response: DEQ and DOGAMI oversee protection of groundwater quality from pollution throughout the region, under OAR 340-040. EHAP does not have regulatory authority over groundwater in any case, which means that EHAP does not have the authority to enforce or require any agencies to perform remediation in the area. Further, EHAP does not have the expertise to determine or verify the source of contaminants in wells. However, EHAP makes recommendations to individual well owners when necessary to reduce or prevent harmful exposures to the consumers of that particular well water.

Water insecurity

Crook County domestic well owners shared challenges related to compromised water quality on their properties and increased fears about ongoing or increasing water insecurity in the future.

Response: OHA's role in addressing ground water quality is assessing risks to public health and regulating public water systems under the Oregon Drinking Water Act, that use ground water as a drinking water source. This Health Consultation assesses health risks from drinking water from the private domestic wells tested. Natural resource agencies, including DEQ implement laws related to ground water quality. However, EHAP is grateful for the opportunity to highlight this community concern. Access to safe and healthy water is critical for health.

Impacts to property values

Community members have reported experiencing anxiety and frustration related to reduced property values because of well contamination.

Response: Although Health Consultations are highly technical reports that are not meant to address social impacts, EHAP is grateful for the opportunity to highlight this community concern. Public health recommendations may impact certain communities (e.g., area property owners) more than others. Routine well testing provides well owners with current information about the quality of their well water and treatment options are available for whole house or point of use well water treatment.

During real estate transactions (RET), the seller must test the well's water quality for arsenic, nitrate and bacteria and share the results and the RET form with the buyer and OHA to comply with the Domestic Well Testing Act. Properties with spring wells, irrigation only wells, or wells located on undeveloped land are exempt from these rules. These rules are meant to protect prospective buyers, however, there is no provision for their enforcement, and sale of the property is not contingent on completion of the testing requirement.

Although the conclusions of this Health Consultation indicate some wells pose increased risk from some contaminants, many wells in this area have low risk. The groundwater samples used in this Health Consultation were taken at the well head, before treatment if possible. Some samples were collected prior to a holding tank and some were taken after moving water through a holding tank, depending on sample port locations. Many of the households that use this water already have treatment systems, meaning that exposure to well contaminants is often lower than the levels estimated in this report. Well owners could sample treated groundwater (i.e., from their kitchen faucets if using a treatment system) to ensure that the well water they consume does not contain contaminants at levels that could increase their risk.

For more information, see the Oregon Health Authority Domestic Well Safety Program webpage.

Dissatisfaction with government agency response

Community members also indicated high levels of stress and frustration over concerns that the health and well-being of their community have been compromised. They also feel that in the past, their community needs and health concerns have not been heard by government agencies. Community members expressed dissatisfaction with government agencies' response.

Response: DEQ and DOGAMI oversee protection of groundwater quality from pollution throughout the region, under OAR 340-040. EHAP does not have technical expertise to identify sources of ground water contamination, or regulatory authority to enforce or require any agencies to perform remediation in the area. EHAP's role and expertise is to make recommendations to individual well owners, when necessary, to reduce or prevent harmful exposures to the consumers of that particular well water.

Discussion

Data used in this Health Consultation

DEQ's contractor, Maul Foster and Alongi, collected samples from 55 domestic wells between November 18 and 25 of 2024. They resampled 52 of the same wells and added a few more for a total of 58 well samples April 28 to May 6, 2025. From here on, EHAP will refer to these events as Fall 2024 sampling and Spring 2025 sampling. The complete contractor report (4) contains additional details about the wells such as well depths and is available here.

DEQ's contractors tested samples for 43 different chemicals, called "analytes." Some of the analytes were contaminants with potential health significance, like arsenic or manganese, while other characteristics, like conductivity and hardness, provide other kinds of information about the water quality but do not have any direct influence on health.

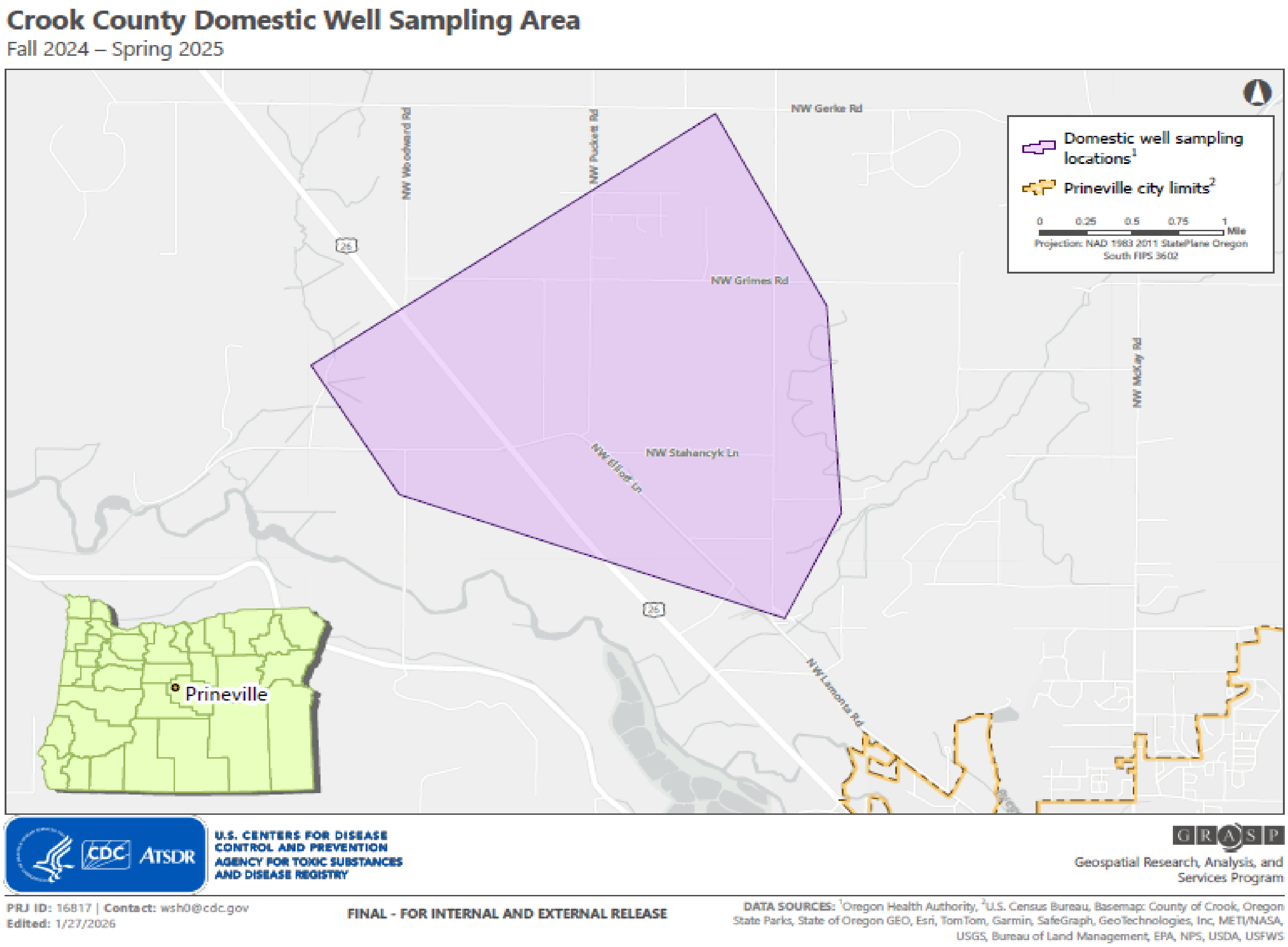
EHAP gave individual well users their results for all analytes as soon as they were available to our program. Along with the results, EHAP provided an individualized health interpretation to each household along with an offer for a real-time conversation with an EHAP toxicologist.

As a document focused on human health, this Health Consultation only displays and discusses the subset of analytes that are contaminants with potential health significance. Appendix A lists these analytes along with summary statistics about results for each. Results for all analytes are available in DEQ's contractor's report here. (4) Data for three of the metals – aluminum, iron, and manganese – were analyzed as "dissolved" and "total." Total metals include the dissolved metals present as very small molecules that can travel deep within and throughout the human body, as well as those that might be present as a suspended particle in the water, which are larger in size. Both dissolved and particulate metal can affect health, and the total category is inclusive of both. Therefore, EHAP used the "total" results for these three metals in this Health Consultation. For the rest of the analyzed metals, total metals was the only option available.

The contaminants found in certain wells at levels of concern for human health were metals, nitrate, and coliform bacteria.

Figure 1 shows the area where DEQ's contractor sampled domestic wells. The consultant's report documents the measures used to ensure good quality water samples in the field and analysis in the laboratory. (4)

Figure 1. Domestic well sampling area



Identifying contaminants of potential concern (COPCs)

The first step in EHAP's process for analyzing well test data was to identify which contaminants were present at high enough levels to potentially affect the health of well users. This process is called identifying contaminants of potential concern. (5) EHAP used Comparison Values (CVs) to screen the maximum concentration of each contaminant from any of the well samples. CVs are chemical-specific screening levels developed by technical experts at OHA's partners in federal agencies (ATSDR and EPA) that EHAP uses to identify contaminants requiring further evaluation. The CVs are set far below levels known to cause harm, so they were very protective of public health. (5)

What are Comparison Values (CVs)?

CVs are contaminant concentrations in a particular medium, such as air, soil, or water, to which humans might be exposed without the likelihood of experiencing harmful health effects. Each CV is specific to a particular contaminant and environmental medium. CVs are set at very low levels and help health assessors make consistent decisions about which contaminant concentrations associated with site exposures might require a closer look.

CV concentrations are calculated as either micrograms per liter (µg/L) or milligrams per liter (mg/L) in water. When a maximum water concentration is below the CV, the contaminant does not require further evaluation since it is not expected to harm health. If the maximum concentration is above the CV, it requires further evaluation and becomes known as a contaminant of potential concern (COPC). (5) Identification of a contaminant as a COPC does not mean harmful health effects will occur, rather it indicates the need to further evaluate whether people are being exposed to harmful levels of the contaminants. (5)

Aesthetic versus health-based contaminants of potential concern

There are two types of CVs for determining COPCs. Most contaminants have a CV to evaluate health effects. Some contaminants also have CVs that evaluate aesthetic problems like taste, odor, appearance, staining of laundry, or effects on plumbing. (6) Community members have reported problems with the taste and appearance of their water as well as scale and slime on plumbing fixtures, so when a contaminant had both health-based and aesthetics-based CVs, EHAP used whichever CV was lower. This approach ensures that neither causes of health nor aesthetic problems are overlooked. Appendix A shows all contaminants screened against the lowest CVs and separated into the two rounds of sampling (Fall 2024 and Spring 2025). Table 1 shows those contaminants that screened in as COPCs based on potential to cause aesthetics problems. Table 2 shows contaminants that screened in as COPCs based on potential to pose health risks, called “health-based COPCs” from now on. Note that manganese appears on both tables with different CVs in each. This is because manganese was present in some wells at concentrations high enough to both cause aesthetics problems and pose a potential health risk.

Aluminum and iron

Aluminum and iron screened only as COPCs for aesthetics – not health. Both metals can cause a metallic taste in the water, and iron can cause rust-colored stains on laundry and white surfaces. (6) This can make the water unpleasant to drink and use, but the levels of aluminum and iron measured in this sampling effort are not high enough, on their own, to cause health problems, even when consumed over a lifetime. This Health Consultation does not contain any more discussion on aluminum and iron because they are not present at levels high enough to harm health in any of the wells tested.

Table 1. Contaminants that screened in as potential causes of aesthetics problems

Chemical	Maximum Reported (µg/L)	Comparison Value (µg/L)		Contaminant of Potential Concern for Aesthetics?	Contaminant of Potential Concern for Health?
		Aesthetics[a]	Health		
Aluminum	1,160	200	7,100[b]	Yes	No
Iron	2,540	300	14,000[c]	Yes	No
Manganese	464	50	300[d]	Yes	Yes

Abbreviations: µg/L = micrograms per liter; ATSDR = Agency for Toxic Substances and Disease Registry; EPA = Environmental Protection Agency

Comparison Value sources:

a. EPA Secondary maximum contaminant level (6)

b. ATSDR exposure media evaluation guide for children

c. EPA regional screening level for children (7)

d. EPA lifetime health advisory level (8)

Table 2. Contaminants that screened in as health-based contaminants of potential concern (COPCs)

Chemical	Maximum Reported (µg/L)*	Comparison Values (µg/L)	Notes
Arsenic	38.6	2[a]	At 2 µg/L and below arsenic still poses slight cancer risk
Copper	143	140[a]	Essential nutrient[e]
Fluoride	1,250	350[a]	Essential nutrient[e]
Lead	47	Detectable	There is no safe level of lead
Manganese	464	300[b]	Essential nutrient[e]
Nitrate (mg/L) [d]	20.7	10[c]	
Vanadium	73.2	71[a]	

*For all analytes, except nitrate, the units are µg/L. For nitrates only, the units are mg/L.

Abbreviations: µg/L = micrograms per liter; mg/L = milligrams per liter; ATSDR = Agency for Toxic Substances and Disease Registry; EPA = Environmental Protection Agency

Comparison Value sources:

a. ATSDR exposure media evaluation guide for children
b. EPA lifetime health advisory level for children (8)
c. EPA Maximum contaminant level (9)
d. Note that units of measurement for nitrate are milligrams per liter (mg/L) rather than micrograms per liter (µg/L).

e. Essential nutrients are elements that our bodies need for good health but cannot produce on their own. Therefore, we need to get them in safe amounts through the things we eat and drink.

Total coliform bacteria

An important health-based COPC is total coliform bacteria. There is not a CV for total coliform the same way that there is for the chemicals listed above in Table 1 and Table 2. This is because safe well water should not have any detectable coliform bacteria. (9) Since total coliform were detected in 13 wells in Fall 2024 and 4 wells in 2025, it is automatically a COPC.

Wells that tested positive for total coliform were also tested for *Escherichia coli* (E. coli), a common pathogenic (or disease causing) member of the total coliform group. None of the wells tested positive for E. coli, but the presence of total coliform indicates that bacteria are getting into the well somehow, so there is always risk of E. coli or another harmful type of bacteria getting in at some point in the future. The source of total coliform bacteria in wells is usually very local to the well head area. Common sources of contamination are breaks in the well seal, livestock near the well head, or nearby failing septic systems. (10) The presence of coliform poses a health risk to those who drink water from the contaminated wells. The recommendation section of this Health Consultation describes steps well owners can take to prevent and get rid of total coliform bacteria in their wells.

EHAP notified well users promptly if their wells tested positive for total coliform bacteria. Of the 13 wells with positive results in Fall 2024, only 4 tested positive again in Spring 2025, indicating that well owners likely took steps to eliminate or reduce bacterial contamination in their wells between Fall and Spring sampling events.

Numbers of wells with health-based COPCs

This section describes how many wells had health-based COPCs. Table 3 shows the number and percent of affected wells for each round of sampling.

Table 3. Number and percentage of wells with health-based contaminants of potential concern (COPCs)

Contaminants of Potential Concern	Fall 2024 Number of wells out of 55 (Percent)	Spring 2025 Number of wells out of 58 (Percent)
Arsenic	51 wells (93%)	55 wells (95%)
Copper	1 well (2%)	0 wells (0%)
Fluoride	7 wells (13%)	13 wells (22%)
Lead	27 wells (49%)	25 wells (43%)
Manganese	5 wells (9%)	5 wells (9%)
Nitrate	10 wells (18%)	9 wells (16%)
Total coliform bacteria	13 wells (24%)	4 wells (7%)
Vanadium	0 wells (0%)	1 well (2%)

Exposure pathways

For a contaminant to harm human health, there must be a way for people to come into contact with it. Following ATSDR's guidance, (5) EHAP conducted an exposure pathway analysis. This describes how a chemical moves from its source and comes into physical contact with people. An exposure pathway has the following five elements:

1. A source where the chemicals originate
2. A medium (for example, air, soil, or water) for a chemical to move through the environment to a place where people could come into contact with it
3. A location (point or area) where people come into contact with the chemical
4. A way (route) through which people have contact with the chemicals (for example, breathing it, swallowing it, or absorbing it through the skin), and
5. A population that comes into contact with the chemical.

When an exposure pathway has all five of these elements it is considered a completed exposure pathway, meaning there is evidence that people have come into contact with site-related contaminants. A potential exposure pathway is when some elements are present but one or more of them is uncertain (such as when a population may be coming into contact with the chemical, but the chemical's presence cannot be confirmed). Finally, an eliminated exposure pathway is when at least one of the five elements of a pathway is not present (such as when a population cannot access contamination because of a fence or other barrier).

In the case of water from Crook County domestic wells, the exposure pathway analysis is very simple. Ingestion and dermal contact with contaminated groundwater from wells is a completed exposure pathway.

Completed exposure pathways

EHAP identified one completed exposure pathway for people to be exposed: swallowing and skin contact with contaminated groundwater from their wells (Table 4).

Table 4. Completed exposure pathways

Pathway	Source	Exposure Location	Exposure Route	Exposure population	Notes
Ingestion of and dermal contact with groundwater	Groundwater	Domestic well water in and around homes	Ingestion and dermal contact	Adults and children in homes with contaminated wells	Completed exposure pathway

Well users are exposed to contaminants in their wells as they drink the water, use it for cooking and beverages, bathe and shower, water gardens/yards, or do general cleaning. The ingestion (swallowing) route of exposure is the most important in this scenario. The COPCs in this case do not pass through the skin efficiently, so skin exposures do not pose much risk. (11) (12) (13) (14) (15) (16) (17) (18) Other characteristics of water in some of the wells (especially hard water) can cause dry skin, which can cause itching and make pre-existing skin problems worse. However, water hardness is not directly related to any of the COPCs listed in Table 3 above.

Inhalation of aerosols or droplets while showering is also not a risk in this scenario. The COPCs in this case would not evaporate with heat (as in a hot shower) and therefore would not be part of the steam inhaled while showering. The amount of aerosols or droplets inhaled while showering are very small compared to the amount swallowed if used for drinking or cooking.

In this scenario, swallowing the water - and not skin contact or inhalation - is the relevant route of exposure to health risks.

Health effects evaluation

Once COPCs and a completed exposure pathway have been identified, the next step in the Health Consultation process is to determine how much of those COPCs could get into a person's body, estimate how much risk they pose, and describe the possible health effects. (5)

EHAP estimated how much of each COPC could get into people's bodies. The amount that gets into people's bodies is referred to as a "dose" in toxicology. EHAP then used the dose to calculate the risk of developing:

- Cancer, and
- Non-cancer health effects (health problems other than cancer).

EHAP developed conservative (reasonable worst-case) exposure assumptions that represent the greatest potential risk to exposed adults and children. This ensures that where there is scientific uncertainty about the risk, the estimated risk represents the highest reasonable exposure, rather than an underestimate.

Using the maximum measured concentration of each COPC from any well in the study and high-end assumptions about the amounts of water children and adults drink, EHAP calculated doses and risk estimates for the COPCs.

Cancer assessment

EHAP estimated cancer risk from drinking groundwater contaminated with arsenic, which is the only COPC known to increase cancer risk that also has the necessary information to quantify risk.

What is 1-in-a-million cancer risk?

Cancer risk is expressed as a *probability* of additional cancer cases in a population. In risk assessment, cancer risk is the estimated number of cancer cases caused by exposure that is *in addition* to cancers from other causes. The American Cancer Society estimates that one in three women and one in two men will get cancer in their lifetime.

A 1-in-a million cancer risk means that one person out of one million people equally exposed to a chemical will get cancer over the course of their lifetime. This would be in addition to the cancer cases from other causes.

Cancer risk can be thought of as additional cancer cases in a population. Cancer risk from environmental exposure is considered in addition to the "background" risk of developing cancer over a lifetime. The American Cancer Society estimates that one in three women and one in two men will develop some type of cancer in their lifetime. (19) These background cancers are attributed to a combination of genetic mutations (a change in a cell that alter how it works), inherited conditions (traits passed on to children), tobacco use and other lifestyle factors, common environmental exposures, and occupational exposures. The contributions of each factor to the incidence of cancer in people and communities are difficult to predict or quantify.

When assessing cancer risk from a site-specific exposure, a cancer risk (or probability) is expressed in terms of chances in a million ($1x10^{-6}$ or 0.000001). For example, a one-in-a-million cancer risk means that for every one million people with that same site-specific exposure for the same amount of time, one additional person could develop cancer (due to that exposure) at some point in their life. This one-in-a-million increase of cancer is in addition to the roughly 400,000 people out of one million (approximate background rate [40%] for men and women combined) that would be expected to get cancer from all causes combined. It is not possible to determine which one of the 400,001 cancer cases is the additional case due to a site-specific exposure.

EHAP considers cancer risk that falls between one additional case of cancer per million people ($1x10^{-6}$) and one additional case per ten thousand people ($1x10^{-4}$) as being low.

Non-cancer assessment

EHAP evaluated the non-cancer risk associated with drinking groundwater from wells tested in the study area. Non-cancer risk can differ depending on whether a person drinks the water for a short time, or "acute exposure" (less than 2 weeks); a long time, or "chronic exposure" (a year or more); or something in between, or "intermediate exposure" (longer than two weeks but less than a year). EHAP uses health guidelines established by ATSDR and EPA to evaluate non-cancer health hazard. Each health guideline is specific to a contaminant, depends on how long someone is exposed, and is designed to be protective of the most sensitive population. (5)

Most COPCs can cause multiple kinds of health problems. When setting health guidelines, ATSDR and EPA determine which of those health problems occurs at the lowest dose. This lowest-dose health problem is called the "critical effect." (5) The reasoning is that if the health guideline is protective against the critical effect, then it will also be protective against any of the other non-cancer health effects that COPC may cause at higher doses. In discussing health risks from individual COPCs later in this document, EHAP will describe how calculated doses of COPCs from wells compare against doses that caused the critical effect for that COPC in the scientific studies used to set the health guideline. Critical effects differ across COPCs.

ATSDR calls their health guidelines "minimal risk levels (MRLs)." (20) EPA calls their health guidelines "reference doses (RfDs)." (21) In this Health Consultation, EHAP used ATSDR MRLs for all COPCs except for manganese. For manganese EHAP used EPA's RfD because ATSDR does not have an MRL for manganese. Even though MRLs and RfDs have different names they are both health guidelines and are made in the same way and for the same purpose.

What is an ATSDR MRL?

A minimal risk level (MRL) is an estimate of daily human exposure to a hazardous substance. It is a prediction of how much someone can be exposed to a chemical without detectable health risks, excluding cancer. **Exposure doses greater than MRLs do not necessarily mean that people will experience the associated adverse effects.**

Health risks depend on the amount of chemical exposure and the amount of time a person is exposed. ATSDR publishes MRLs for different exposure lengths (i.e., one chemical may have different MRLs depending on the length of exposure time):

Chronic MRL – For exposures of one year or longer.

Intermediate MRL – For exposures lasting more than two weeks up to 1 year

Acute MRL – For exposures of two weeks or less.

Hazard Quotients

To determine the non-cancer hazard from the COPCs in groundwater from Crook County wells, EHAP calculated a hazard quotient (HQ). The HQ is a ratio used to assess the potential health risks associated with exposure to hazardous substances, calculated by comparing the level of exposure, or dose, to the health guideline. (5) When an HQ is less than 1.0 (the exposure is lower than or equal to the health guideline), it is unlikely that non-cancer health effects will occur. If it is equal to or greater than 1.0 (the exposure is higher than the health guideline), there is a need for more in-depth analysis to determine whether an exposed person could experience adverse health effects that are not cancer. (5) Not all HQs greater than 1.0 result in a conclusion of harm. For example, an HQ of 5 in one situation for one contaminant may result in a conclusion of high health risk. However, it might not for another contaminant in another situation. Conclusion of health risk depends on several factors, such as:

- The severity and permanence or reversibility of the health effect underlying the health guidelines

- The degree of certainty in the science underlying the health guideline (health guidelines for different chemicals have variable levels of uncertainty built in based on the underlying toxicological studies)
- Characteristics of the exposed population that might make them more or less sensitive to the health effects of the contaminant (such as age), and
- The degree of certainty about the measured or modeled concentrations of the contaminant and how representative they are of the conditions to which people are exposed.

Health risk conclusions are not direct outcomes of calculated HQs. However, HQs are useful tools to determine when there is a need for in-depth analysis. EHAP's conclusions result from an in-depth analysis of the above factors that vary by exposed population and contaminant. See the In-depth analysis section of this report for more information about which factors were considered to evaluate health risks from individual COPCs.

When a person is exposed to more than one contaminant in the same medium (water or soil), EHAP can calculate the total non-cancer risk posed by all the contaminants. EHAP does so by adding the HQ for all the COPCs together, which yields a hazard index (HI). (5) As with HQs, an HI less than or equal to 1 means that non-cancer health effects for the whole mixture of COPCs are unlikely, while an HI greater than 1 would trigger an in-depth analysis of the mixture. However, in this case it is not scientifically valid to add non-cancer risks from different contaminants because the maximum concentrations of COPCs are all taken from different wells (whichever well had the highest concentration for each COPC). In other words, no one is drinking water from a single well with the maximum concentrations of every COPC.

EHAP used the maximum concentrations of each COPC rather than an average because people do not drink equally from all sampled wells in the area. Rather, they drink most of their water from their own well. Therefore, an average COPC concentration across wells would not be representative of water that any one individual drinks.

Lead

There is no safe level of lead. (5) Therefore, there is no health guideline for it, and lead is considered a COPC whenever it is detected in any amount. Without a health guideline, EHAP cannot calculate an HQ and evaluate it in the same way as the other COPCs. The section on lead in the “In-depth analysis” section explains how EHAP evaluated risks from lead.

Health risks from groundwater from sampled wells in Crook County

This section contains a high-level summary of the health risks from drinking groundwater with the highest concentrations measured for each health-based COPC in the well sampling effort in Crook County. Appendix B contains much more detailed tables of risk broken down by age group. Appendix B also explains how EHAP did the risk calculations and what assumptions EHAP made. EHAP followed ATSDR guidance in all dose and risk calculations in Appendix B.

Table 5 shows only the maximum chronic health risks for children under 1 year old and adults (age 21 and older) for each COPC. Formula-fed infants from age 0 to 1 year get the highest doses of COPCs in water because they drink the most water per body weight. Older children and adults will always have lower doses, and therefore lower risk compared the 0 to 1 year-old children. By calculating HQs and cancer risk for these young children, EHAP is including the most exposed and highest risk group and making sure no risk is missed. Appendix B shows cancer risk and HQs for more age groups within childhood. Chronic risk means risk from exposures lasting 1 year or longer. A well with lower or non-detectable levels of a given contaminant will have lower or no risk compared to what is shown in Table 5.

Table 5. Summary of health risk numbers for chronic exposures (those that last 1 year or longer)

	Noncancer hazard quotient[a]		Cancer (chances out of 10,000)	
Contaminant of potential concern	**Child under 1 year**	**Adult**	**Child (ages 0-21 years)**	**Adult**
Arsenic	90	30	Greater than 60[b]	Greater than 60[b]
Copper	---	---	---	---
Fluoride	4	1	---	---
Manganese	1	0.4	---	---
Nitrate	3	0.9	---	---
Vanadium	---	---	---	---

Blue shading indicates a need for in-depth analysis; "---" means no health guideline value is available for that contaminant for that type of risk, so no risk calculation was possible.

a. All hazard quotients are rounded to 1 significant digit; a hazard quotient that is 1 or more indicates the need for a more in-depth analysis. Hazard quotients less than 1 mean no health effects are expected, and no further analysis is needed.

b. EHAP used the linear slope factor from EPA's integrated risk information system (IRIS) to calculate cancer risk from arsenic exposure. The resulting cancer risk is greater than 60 in 10,000, which is a concern for increased cancer risk. EPA's toxicological review (22) states that the linear slope factor is not accurate at lifetime doses greater than 0.2 µg/kg/day, which equates to a cancer risk of 60 in 10,000. Because the cancer risk is so high, the exact risk level is not needed to determine that the exposure is a concern.

Table 6 shows the maximum intermediate and acute risks for children and adults. Acute risk means risk from exposures that last 2 weeks or less. Intermediate risk means risk from exposures that last more than two weeks up to 1 year. If water poses acute or intermediate risk, it also poses chronic risk. For wells with less than the maximum concentration of a given COPC, the risk is lower or there may even be no risk compared to what is shown in Table 6. Cancer risk is not included in Table 6 because COPCs can only cause cancer after chronic exposure.

Table 6. Summary of health risk numbers for acute and intermediate exposures

	Acute[a] hazard quotient[c]		Intermediate[b] hazard quotient[c]	
Contaminant of potential concern	**Child under 1 year**	**Adult**	**Child under 1 year**	**Adult**
Arsenic	1	0.3	---	---
Copper	1	0.3	1	0.3
Fluoride	---	---	---	---
Manganese	---	---	---	---
Nitrate	3	0.9	3	0.9
Vanadium	---	---	1	0.3

Blue shading indicates elevated risk and need for in-depth analysis; "---" means no health guideline value is available for that contaminant for that type of risk, so no risk calculation was possible.

a. Acute means exposures that last 2 weeks or less

b. Intermediate means exposures that last more than 2 weeks up to 1 year

c. All hazard quotients are rounded to 1 significant digit; a hazard quotient that is 1 or more indicates the need for a more in-depth analysis. Hazard quotients less than 1 mean no health effects are expected, and no further analysis is needed.

In-depth analysis

This section consists of the in-depth analysis for all health-based COPCs with a hazard quotient of one or greater for the highest concentration of each contaminant. Note that arsenic and fluoride are the only COPCs with hazard quotients at or greater than 1 for adults in regards to chronic (greater than one year) exposure. For the most part, young children are the most at risk from measured levels of contaminants in well water.

Health risks from arsenic

The highest concentration of arsenic measured in any well in the study was 38.6 µg/L. Arsenic has the potential to cause both cancer and non-cancer health effects.

<u>Cancer</u>

At 38.6 µg/L arsenic, the excess lifetime cancer risk to both adults and children that drink the water over the course of several years is greater than 60 in 10,000. **EHAP considers this a high risk and a health hazard.**

The lowest level of arsenic measured in any well was 1.1 µg/L. At this concentration, the excess lifetime cancer risk is 4 in 10,000 for children, who drink the water for 21 years (i.e., until they are no longer considered children) and 6 in 10,000 for adults who drink the water for 33 years. This is an elevated level of cancer risk by the standards described above (see Cancer section). However, arsenic is very common in domestic drinking water wells in Oregon. See additional information at the bottom of this section, “A note about the maximum contaminant level (MCL) for arsenic.”

<u>Non-cancer</u>

Acute: The critical effect for acute exposure to arsenic is facial swelling, nausea, vomiting, and diarrhea in children. (11) The acute HQs associated with the highest measured concentration of arsenic in well water (38.6 µg/L) are 0.3 for adults and 0.45 or less for children 1 year or older. This means that there are no acute health risks to adults or children older than 1 year from arsenic in any of the wells sampled.

The acute HQ for children from 0 to 1 year at the highest level of arsenic measured in the study is 1.

The calculated acute dose to children (5.5 µg/kg/day), is about 10 times lower than the dose that caused acute health problems (facial swelling, nausea, vomiting, and diarrhea) in young children in studies (50 µg/kg/day). (11) Water with concentrations of arsenic at or below the acute comparison value for children of 35 µg/L poses no acute health risks to anyone.

EHAP concludes that drinking water with arsenic concentrations at the maximum level measured in the study 38.6 µg/L poses **significant non-cancer health risks to children under 1 year-old** who drink the water in the short-term (1 day or longer)**.** There are no significant health risks to adults or children older than 1 year from arsenic from exposures lasting less than 1 year.

Intermediate: There is no intermediate MRL for arsenic, so EHAP was not able to calculate risk for intermediate exposures to arsenic. However, there is enough information to make determinations for acute risk, which apply to intermediate-length exposures as well.

Chronic: The critical effect for chronic exposure to arsenic is wart-like skin lesions and changes to blood vessels in the skin. (11)

The chronic HQs associated with the highest concentration of arsenic measured in any well (38.6 µg/L) were 90 for children and 30 for adults.

The estimated chronic doses to children (5.5 µg/kg/day) and adults (1.6 µg/kg/day) are in the same range of doses where studies in humans (11) have shown effects on:

- Skin - small “corns” or “warts” on the palms, soles, and torso as well as changes in the blood vessels of the skin (Critical effect)
- Blood - anemia during pregnancy
- Liver- increased signs of liver damage, like alkaline phosphatase and bilirubin, in serum
- Cardiovascular system – strokes, heart palpitations and poor circulation to extremities

- Nervous system - decreased performance on neurobehavioral tests in children
- Reproductive system - increased incidence of spontaneous abortion
- Development – low birthweight

Water containing 2 µg/L or less of arsenic results in an HQ of 1 or less for all ages, meaning non-cancer health effects would not be expected in anyone at that level.

EHAP concludes that drinking water with arsenic concentrations at the maximum level measured in the study 38.6 µg/L for a year or more poses **significant non-cancer health risks to adults and children**.

A note about the maximum contaminant level (MCL) for arsenic

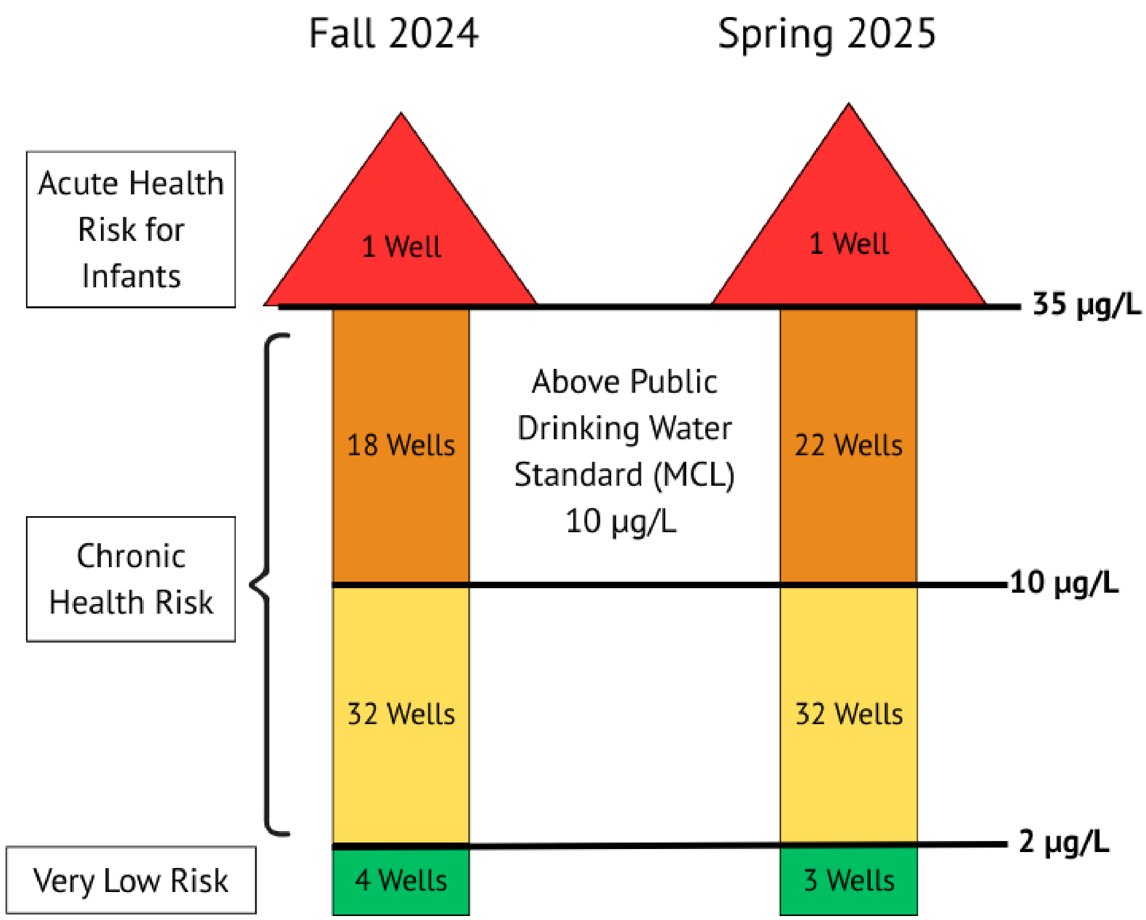
The maximum contaminant level (MCL) is an enforceable standard that public water systems are required to meet. (9) For arsenic the MCL is 10 µg/L. (9) At 10 µg/L, excess lifetime cancer risk is 40 in 10,000 for children and 60 in 10,000 for adults who drink the water over several years. Water containing 10 µg/L arsenic also poses some chronic non-cancer health risks to children and adults who drink the water for a year or more.

MCLs, developed by the US EPA, are not strictly health-based and include considerations of the technical feasibility and capacity of public water systems to meet them. (9) MCLs apply only to public drinking water systems, so no government agency enforces MCLs on private domestic wells.

Arsenic is a very common element in the earth's crust and may always be present at some level in soil and groundwater. (11) Wells with arsenic above the MCL are very common in Oregon. Wells with arsenic above 2 µg/L are even more common.

Figure 2 shows the number of sampled Crook County wells that fall into different categories of concern for arsenic.

Figure 2. Arsenic results from Crook County domestic well sampling



Health risks from copper

The highest concentration of copper measured in any well in the study was 143 µg/L. The result was much lower (13.2 µg/L) in a duplicate sample collected at the same time from the same well. This indicates the potential for elevated results due to copper particles in the water sample or a laboratory error. Copper only screened in as a contaminant of concern in one well from the Fall 2024 sampling round and none in the Spring 2025 sampling round. Therefore, this in-depth analysis is only applicable to one well at one time point. For all other wells, levels of copper were too low to harm health.

Copper is an essential nutrient, so people can become ill from not getting enough copper as well as from getting too much. (13)

<u>Cancer</u>

Copper is not known to cause cancer. (13)

<u>Non-cancer</u>

Acute and Intermediate: ATSDR uses the same MRL for both acute and intermediate exposures, so the in-depth analysis of non-cancer health risks is the same for acute and intermediate. The critical effect for acute and intermediate exposures to copper in drinking water is abdominal pain, nausea, and vomiting. (13)

At the maximum concentration measured (143 µg/L), the HQ was 0.3 for adults and 1 for children under 1 year old. For children 1 year and older, the HQs range from 0.2 to 0.4. This means that even in the well with the highest level of copper measured, only children under 1 year old are at potential risk and not adults or children older than 1 year.

The calculated dose to a child under 1 year old drinking the water from this highest copper well was 20 µg/kg/day which is only 3.5 times lower than the dose (70 µg/kg/day) shown to cause abdominal pain, nausea, and vomiting in studies in humans after only 2 weeks. (13) EHAP concludes that drinking well water with copper levels higher than 140 µg/L for 2 weeks or less **increases the risk that children under 1 year old will experience abdominal pain, nausea, and vomiting**. Water with copper levels of 140 µg/L or lower pose no health risks to anyone.

Note that people with a rare genetic disorder called Wilson's disease are at increased risk from copper exposure. People with Wilson's disease have an impaired ability to process copper and regulate internal levels. (13)

Chronic: There are no available health guidelines for chronic exposure to copper, so EHAP could not evaluate non-cancer risks from chronic exposure. However, the human body is well suited to regulate internal levels of essential nutrients like copper as long the dose is not so high that it causes health problems following acute or intermediate exposures (described in previous subsection). Water over

140 µg/L that is high enough to increase health risks from acute or intermediate exposures would increase risk from chronic exposures as well.

Health risks from fluoride

The highest concentration of fluoride measured in any well in the study was 1,250 µg/L. While fluoride is necessary for good dental health, too much of it can be harmful.

Cancer

Fluoride is not known to cause cancer. (14)

Non-cancer

Acute and Intermediate: ATSDR does not have an acute or intermediate MRL for fluoride, so EHAP could not evaluate non-cancer risks from acute or intermediate exposure to fluoride. However, for most chemicals, health effects from acute exposure usually require a much higher dose than health effects from chronic exposure.

Chronic: The critical effect for chronic exposure to fluoride is increased bone fractures in the elderly. At higher doses it can also cause staining and pitting of teeth (fluorosis). (14)

At 1,250 µg/L, the HQs from exposures lasting a year or more were 4 for children under 1 year old and 1 for adults. HQs for children older than 1 year ranged between 1 and 0.8.

EHAP calculated a dose of 180 µg/kg/day for children under 1 year old drinking water with fluoride at 1,250 µg/L. This calculated dose (180 µg/kg/day) is about 1.4 times lower than the dose (250 µg/kg/day) that caused an increased prevalence of bone fractures in humans that had fluoride in their water. However, in this study, the increased risk of bone fractures was most pronounced among the elderly, who are already at increased risk for bone fractures compared to younger people. (14) Children have much lower risk of bone fractures overall, making them much less susceptible to this critical effect than elderly adults. In this scenario, the population consuming the highest dose is also the population that is least susceptible to the critical effect.

Adults drinking water with the highest concentration of fluoride measured in any well (1,250 µg/L) would get an average daily dose of 50 µg/kg/day, which is a dose that did not show any increased prevalence of bone fractures in the same human drinking water study. (14)

Fluoride in water is also effective at preventing dental cavities. Many public water systems add fluoride to the drinking water. The optimal concentration to prevent dental cavities is 700 µg/L. (23) The World Health Organization’s (WHO’s) recommended upper limit for fluoride in public water systems is 1,500 µg/L. (24)

Recent studies have shown that there may be a link between fluoride and impaired neurodevelopment in children. However, none of those studies showed this effect when fluoride levels in water were lower than the WHO’s recommended upper limit of 1,500 µg/L. (25) Concentrations of fluoride were below the WHO’s recommended upper limit in all the domestic wells included in this study.

Overall, EHAP concludes that levels of fluoride measured in wells in Crook County **are too low to harm the health of people who drink it.** In some wells, the levels of fluoride are in the optimal range to prevent dental cavities.

Health risks from lead

There is no safe level of lead exposure, so EHAP uses a different method to describe health risks. Rather than calculating a dose and an HQ, EHAP followed ATSDR’s guidance (5) to use an EPA mathematical model (26) that estimates the probability that a person drinking the affected water would have a blood lead level (BLL) higher than 3.5 µg/deciliter (dL). The Centers for Disease Control (CDC) have established the BLL of 3.5 µg/dL as a blood lead reference value (BLVR), which is a population-based measurement. It is based on the 97.5th percentile of the BLL distribution in U.S. children ages 1-5 years. It is not a health-based threshold, but rather a guide for federal, state, and county public health officials to prioritize communities and children that need focused exposure prevention. (27)

Health-Based Versus Population-Based Assessment

Health-based assessment methods evaluate levels of exposure to chemicals in the context of levels known to cause harm to health.

Population-based assessment methods evaluate levels of exposure to chemicals in the context of how much is typically seen in a population.

Public water systems use a value of 15 µg/L of lead at 10% of taps tested throughout their distribution system to determine if they have a corrosivity problem that causes leaching of lead from plumbing fixtures. However, this value has no legal applicability to domestic wells, and it is not health-based. (28)

Cancer

Federal and international agencies have determined that lead is likely to cause cancer. (15) However, these agencies have not developed the kinds of information EHAP would need to calculate a quantitative cancer risk from lead the way EHAP did for arsenic above. Without that calculation, EHAP cannot know how likely the levels of lead measured in this study are to cause cancer in the people who drink it.

Non-cancer

Lead targets many organs and causes many different health problems, but the critical effect is decreased IQ and other neurodevelopmental/neurobehavioral problems in children who are exposed. (15)

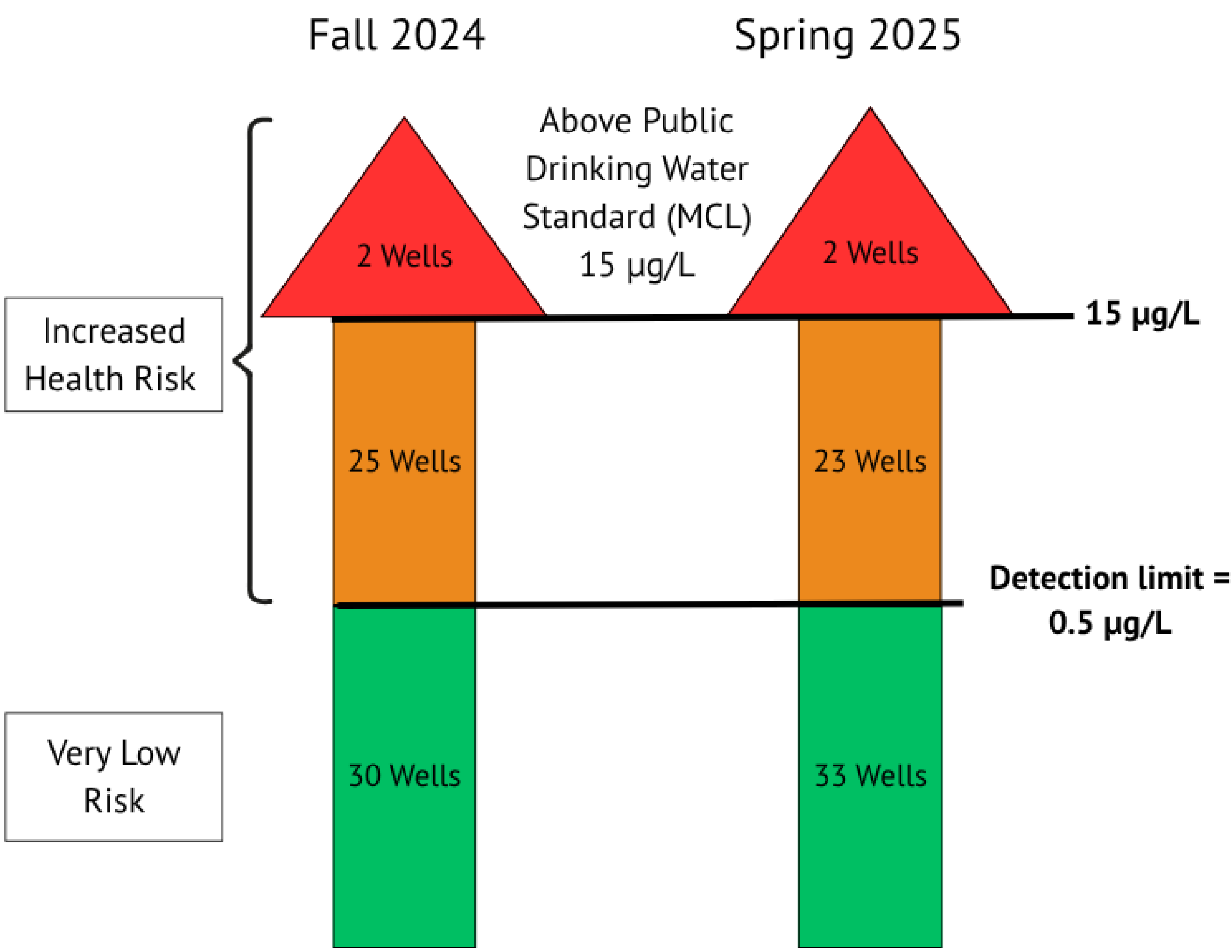
The highest concentration of lead measured in any well in the study was 47 µg/L. Assuming there are no other significant or unusual sources of lead exposure, a 6 month-old child would have a 94.7 percent chance of having a BLL greater than 3.5 µg/dL as a result of this lead in the drinking water, and a 5 year-old child drinking water with this concentration of lead has a 69.5 percent chance. See Appendix C for model details.

Wells with detectable lead have **some risk of raising BLLs to levels that could impair brain development and cause decreases in IQ in children**.

The most likely source of lead in drinking water is plumbing, plumbing fixtures, and old well components or water storage tanks. (29)

Figure 3 shows the number of wells that fall into different categories of concern for lead.

Figure 3. Lead results from Crook County domestic well sampling



Health risks from manganese

The highest concentration of manganese measured in any well in the study was 464 µg/L. Manganese is an essential nutrient, so it is important to have some in the diet and water. However, too much manganese can be harmful. (16)

As discussed earlier, manganese can cause water to taste, smell, and look bad at concentrations much lower than the levels necessary to cause harm to health. Manganese can cause a black sedimentation and staining of laundry and household surfaces. It can also look cloudy and taste metallic. At around 50 µg/L, manganese can start to have these characteristics making it unpleasant to use and drink. EHAP used EPA's lifetime health advisory (LTHA) level (8) of 300 µg/L as a health-based CV to screen manganese in as a health-based COPC.

Cancer

Manganese is not known to cause cancer. (16)

Non-cancer

Acute: ATSDR does not have an acute MRL for manganese, so EHAP could not evaluate health risks for short-term exposures. However, for most chemicals, health effects from acute exposure usually require a much higher dose than health effects from chronic exposure.

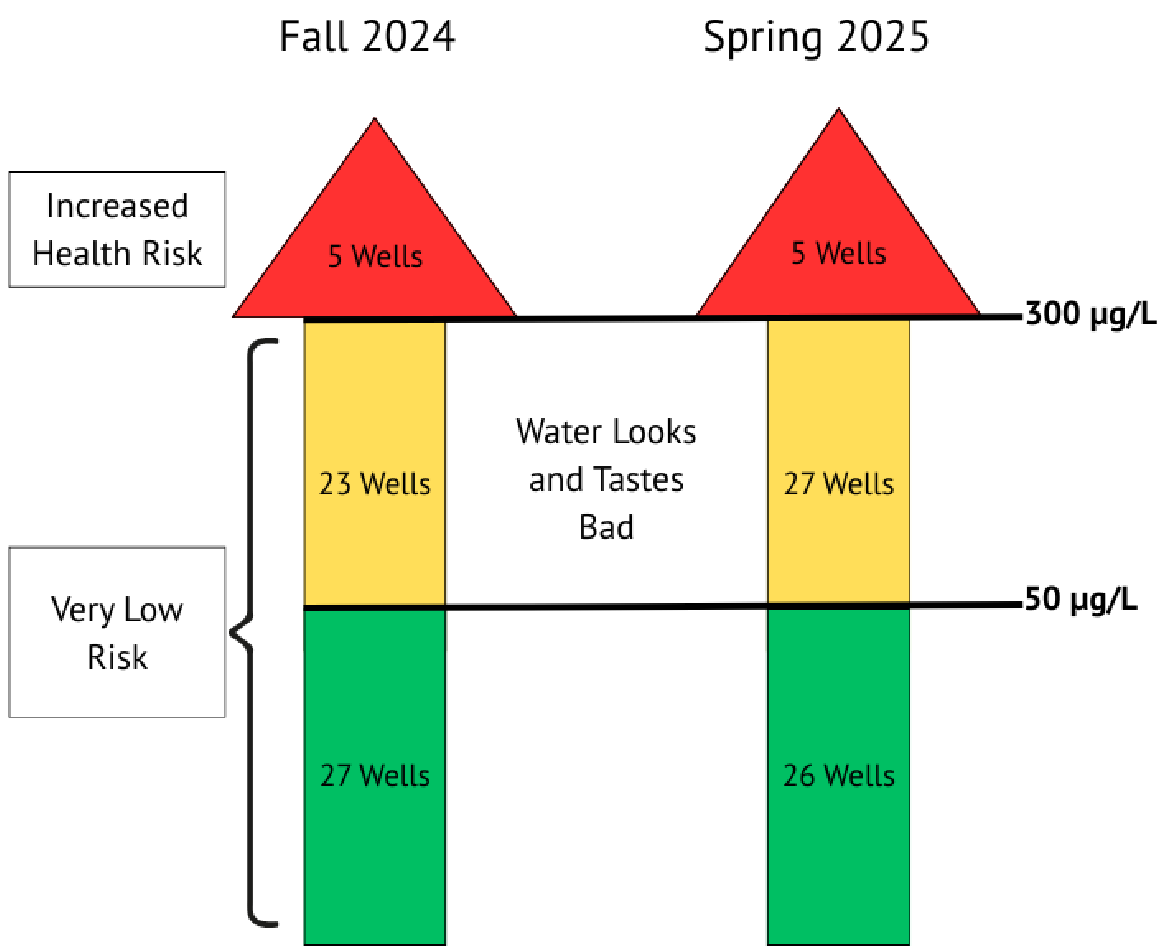
Intermediate: Same as acute.

Chronic: The critical effect for chronic exposure to manganese is an increased risk of neurobehavioral and cognitive problems in school-aged children. (16) At 464 µg/L (the highest concentration measured in this study), a child aged 0-1 year drinking the water for a year would have an HQ of 1, while a child 1 year old and older would have an HQ of 0.6 or less. An adult drinking the water over the same amount of time would have an HQ of 0.4. Therefore, manganese levels are too low to harm the health of children over 1 year old or adults who drink the water even in the well with the highest manganese levels measured in this study.

A child under 1 year-old drinking water with 464 µg/L of manganese would have an estimated daily dose of 66 µg/kg/day, which is about the same as estimated doses in human studies (ranging from 59 to 70 µg/kg/day) that were associated with reduced performance on IQ and other cognitive and neurobehavioral tests in school-aged children who had been exposed through their drinking water over many years. (16) EHAP concludes that children (under 1 year old) who drink water for a year with manganese levels over 300 µg/L are **at increased risk of neurobehavioral and cognitive problems.** Older children (older than 1 year) and adults are not at risk of these problems even if drinking from the well with the highest concentrations measured in this study.

Figure 4 shows the number of wells that fall into different categories of concern for manganese.

Figure 4. Manganese results from Crook County domestic well sampling



EHAP evaluated manganese the same way as other contaminants. In practice, the murky appearance and bad taste of the water make it unlikely that any resident, but particularly children under 1 year of age, would consume water at the highest levels detected. This would protect children from the health effects caused directly by higher levels of manganese.

However, the inconvenience and stress caused by not having water that is good to drink could affect health less directly. For example, people might not drink as much water as is recommended for good hydration, and stress itself can lead to negative health effects.

Health risks from nitrate

The highest concentration of nitrate measured at any well in this study was 20.7 mg/L.

Cancer

There is weaker evidence from research studies in some human populations that nitrate may increase the risk of cancers of the stomach. However, the link is not certain enough to allow for quantitative estimates of the probability of getting cancer from exposure. (18)

Non-cancer

Acute, intermediate, and chronic: ATSDR uses the same MRL with the same critical effect for acute, intermediate, and chronic exposure. The critical effect is methemoglobinemia (or blue-baby syndrome) especially in formula-fed infants under 1 year of age. People with this condition have red blood cells that are less able to carry oxygen throughout the body. It is a condition that can become serious and life threatening quickly in infants. Symptoms include blue skin and lips, rapid heart rate, decreased blood pressure, shortness of breath, headache, dizziness or lightheadedness, nausea and vomiting. (18)

At the highest measured concentration of nitrate (20.7 mg/L), a child under the age of 1 year drinking the water would have an HQ of 3. Children older than 1 year, up to 6 years of age would still have an HQ of 1. Children 6 years and older along with adults drinking water at this highest concentration (20.7 mg/L) would have HQs ranging from 0.7 to 0.9.

A child under 1 year old drinking this water would get a dose of 13 mg/kg/day, which is in the range that could put an infant at risk of methemoglobinemia, or blue baby syndrome. (18)

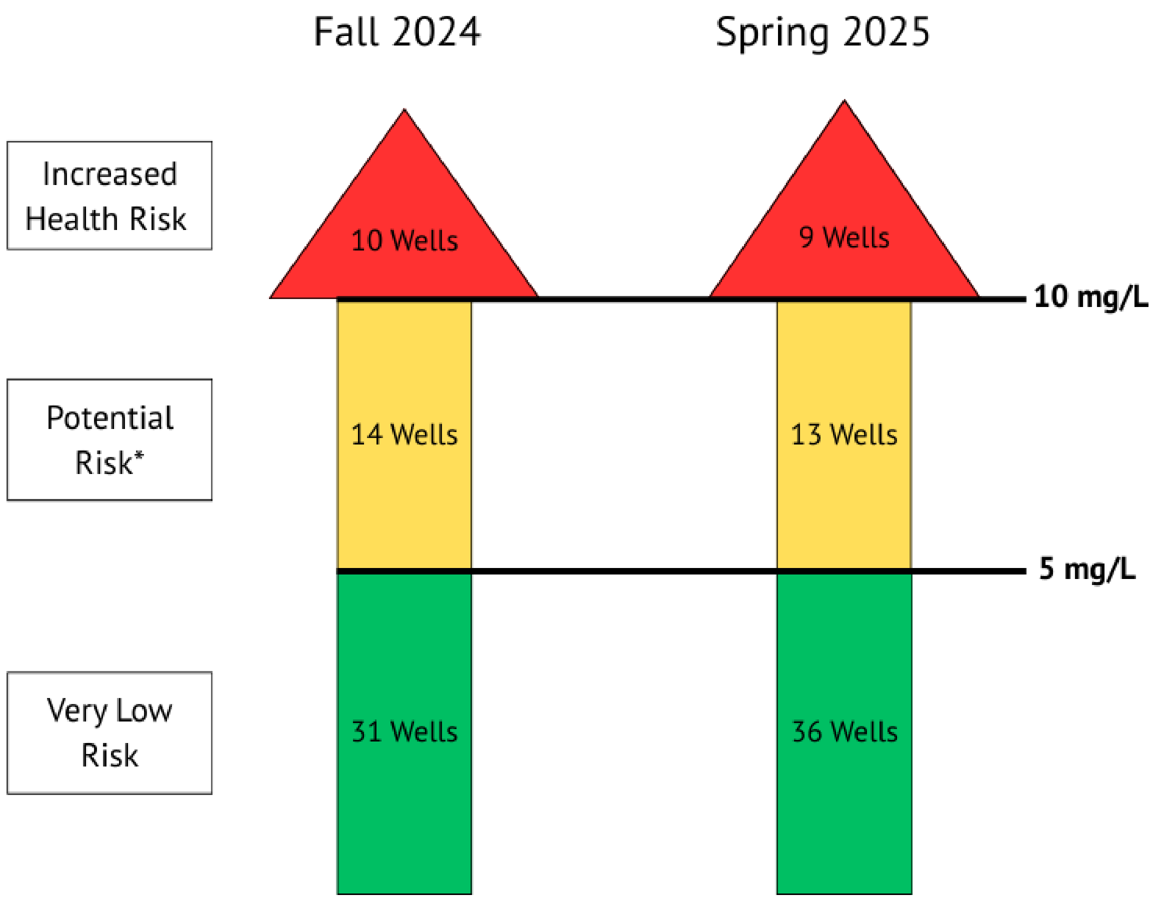
Beyond methemoglobinemia, there is weaker evidence linking nitrate to thyroid problems and developmental effects. (18)

EHAP concludes that **children under 6 years old who drink water with nitrate over 10 mg/L are at increased risk of methemoglobinemia.** Older children and adults are at lower risk for methemoglobinemia but may be at increased risk of cancers of the stomach and thyroid problems if they drink the water for many years.

Women in later stages of pregnancy (third trimester) may be at increased risk of spontaneous abortion (miscarriage) because of the high blood-oxygen demand at this stage, which may be compromised by the impaired oxygen-carrying capacity of blood caused by nitrate over 10 mg/L in drinking water. (18)

Figure 5 shows the number of wells that fall into different categories of concern for nitrate.

Figure 5. Nitrate results for Crook County domestic well sampling



*Wells with nitrate between 5 and 10 mg/L do not pose a health risk, however nitrate levels in this range indicate that nitrate may be infiltrating the well. This means levels could fluctuate seasonally with different water table levels and runoff conditions. There is potential for wells in this range to fluctuate above 10 mg/L at some times of year.

Health risks from vanadium

The highest concentration of vanadium measured at any well in the domestic well study was 73.2 µg/L.

<u>Cancer</u>

There is some evidence in animals that vanadium may increase the risk of cancer when inhaled (17), but the link is too uncertain to calculate cancer risk probabilities from exposures through drinking water.

Non-cancer

Acute: ATSDR does not have an acute MRL for vanadium, so EHAP is not able to evaluate acute non-cancer health risks. However, for most chemicals, health effects from acute exposure usually require a much higher dose than health effects from chronic or intermediate exposure.

Intermediate: The critical effect for vanadium from intermediate exposures is changes to the blood and blood pressure. (17) A child under 1 year old drinking water with the highest concentration of vanadium measured in this study (73.2 µg/L) would have an HQ of 1 while children 1 year and older and adults would have HQs ranging from 0.2 to 0.4. Only children under 1 year old have an HQ requiring an in-depth analysis at the highest concentration measured in this study. Children over 1 year old and adults are not at risk even at the highest concentration measured.

A child under 1 year old drinking water with 73.2 µg/L would have an average daily dose of vanadium of 10 µg/kg/day, which is twelve times lower than a dose (120 µg/kg/day) that caused no health problems in humans exposed via dietary supplements but caused a slight increase in blood pressure in rats. (17) EHAP concludes that this 12-fold safety buffer is adequate to protect the health of children under 1 year old.

EHAP concludes that **levels of vanadium in the wells tested are too low to harm the health of anyone who drinks it**, even in the well with the highest measured levels.

Chronic: ATSDR does not have a chronic MRL for vanadium, so EHAP was not able to evaluate chronic risk directly. However, children ages 0-1 year were the only group with an HQ requiring in-depth analysis for intermediate exposure (more than 2 weeks but less than 1 year). A child can only be aged 0-1 year for less than a year, so chronic exposure is not possible for this age group. Since the risk is low for intermediate exposures even for children aged 0-1, it is not likely that risk from chronic exposure is a concern.

Summary of health risks by contaminant of concern

Table 7 summarizes which COPCs EHAP concludes pose a real health hazard in this situation. It is important to remember that EHAP used the maximum concentration of each COPC regardless of which well it came from, so the conclusions of harm in Table 7 only apply to those wells that have elevated levels of each COPC. Many wells had low concentrations of all of the COPCs, and in those cases EHAP does not anticipate any health risks for the people who drink it.

Table 7. Summary of EHAP's conclusions about health risks by contaminant of potential concern

Contaminant of Potential Concern	Possible harm to health			
	Cancer risk* from chronic exposure	Non-cancer risk† from chronic‡ exposure	Non-cancer risk† from intermediate€ exposure	Non-cancer risk† from acute¥ exposure
Arsenic	Yes	Yes	Yes	Yes
Copper	No	Yes	Yes	Yes
Fluoride	No	No	No	No
Lead	Potential	Yes	Yes	Yes
Manganese	No	Yes	Potential	Potential
Nitrate	Potential	Yes	Yes	Yes
Vanadium	No	No	No	No
Total Coliform	No	Yes	Yes	Yes

Cells with orange shading indicate when health may be harmed and applies to wells with elevated levels of that contaminant (See Tables 2 and 3).

Cells with blue shading means that EHAP concludes there is potential for some risk but does not have enough information to calculate risk for this category.

Contaminant of Potential Concern	Possible harm to health			
	Cancer risk* from chronic exposure	Non-cancer risk† from chronic‡ exposure	Non-cancer risk† from intermediate€ exposure	Non-cancer risk† from acute¥ exposure

*Cancer risk refers to the probability to develop cancer over a lifetime related to contaminant exposure from drinking well water.

†Non-cancer risk refers to the risk of developing a health problem other than cancer. See text in the "In-depth analysis" section of the report for details about health effects for each contaminant of concern.

‡Chronic refers to exposures that last longer than one year.

€Intermediate refers to exposures that last longer than two weeks but less than 1 year.

¥Acute refers to short-term exposures less than 2 weeks.

For the wells affected, the COPCs of highest priority for health are arsenic, lead, nitrate, and total coliform. This is because these are the contaminants with the most serious potential health effects and because they affect the most wells and have the highest HQs in the affected wells. In this study none of the wells were affected by all these high priority COPCs together. Rather it is usually just one and occasionally two of them in a single well.

Limitations and uncertainties

In any Health Consultation, there are uncertainties involved in assessing public health risks from exposure to contaminants and other conditions in the environment. Health Consultations require the use of assumptions, judgments, and limited data sets. The assumptions used in this report's dose calculations are based on a reasonable estimate that has been derived from various studies. Ultimately, EHAP made conclusions based on assumptions that reflect the highest exposure reasonably expected to occur from drinking water from wells tested in this domestic well sampling study.

The Crook County Wells Health Consultation has limitations and uncertainties that are listed below.

Community concerns

EHAP documented a wide variety of community concerns that were shared over several years either directly with EHAP, from local officials and from media coverage. It is possible that there are additional community concerns that were not shared with EHAP and therefore are not discussed in this Health Consultation.

Data limitations

DEQ and their contractor provided high quality data on the wells that were sampled. Duplicate, blank, and control samples all showed that data quality objectives were met and that the data can be relied upon for the purposes of this Health Consultation.

That said, there are always uncertainties and limitations around environmental sampling data. It is only possible to know the concentrations of the contaminants measured at the times of sampling. Contaminants known to fluctuate seasonally, like nitrate, may have different concentrations than measured in this study at other times of year, and levels of contaminants may have been different in the past than at the times of sampling for this study.

State agencies only know the levels of chemicals and characteristics of these wells that were measured. DEQ and their contractor targeted analytes that made the most sense based on the kinds of concerns community members raised and based on the geology of the area and the objectives of the study. However, EHAP cannot rule out the presence of other contaminants that DEQ and their contractor did not test for, such as pesticides or solvents.

Health guidelines and people

Some of the uncertainty in this Health Consultation is related to the health guidelines used to assess toxicity (for example, MRLs). These values have passed a rigorous multi-agency peer-review process. However, each person is unique. People vary in their sensitivity to toxic chemicals. There is increasing evidence that children, pregnant women, the elderly, and people with chronic health conditions are more sensitive to the effects of environmental exposures.

These types of uncertainties are addressed by applying uncertainty factors (dividing the doses where effects were observed in studies by numbers typically ranging from 10 to 1,000). This has the effect of lowering the level at which a chemical is considered toxic. This practice intends to be protective of health by building in a safety boundary to these guidelines.

There is also some uncertainty in health guideline values related to how recently ATSDR, EPA, and other health agencies reviewed scientific literature. More recent research may begin to identify more health effects that can occur at doses lower than those used to establish the health guidelines. EHAP relies on these authoritative federal agencies to periodically review new literature and consider whether the overall weight of evidence suggests a need to revise guidelines, but such reviews happen infrequently.

Missing health guidelines

Health guidelines were not available for every exposure time period (i.e. acute, intermediate, chronic) for every COPC. In cases where no acute MRL was available but risk was low for chronic or intermediate exposure, then risk is most likely low for acute exposures too. This is because it generally takes a larger amount of a toxic chemical to cause health problems over a short time than over a long time.

When there is a missing chronic MRL, but there is an intermediate MRL, there is uncertainty about whether the intermediate MRL is protective of chronic exposures. There is nothing EHAP can do to mitigate this uncertainty. In the case of COPCs that are essential nutrients, like copper, our bodies have systems to internally control the levels of those elements. As long as those systems are not overwhelmed by large exposures in the short-term, then health problems from long-term exposures are unlikely.

Dose reconstruction

Another area of uncertainty has to do with the dose reconstruction (the estimation of actual chemical dose by using exposure factors). This type of uncertainty has two parts:

1. The concentration of chemicals in the well water, and
2. The amount of water people drink.

EHAP used the maximum measured concentration for each COPC. This is intended to be protective of health by evaluating the worst-case well.

EHAP cannot know exactly how much:

- Water each person drinks (including food and beverage preparation)
- Each person weighs, or
- Total time each person drinks water from a well.

In the absence of that type of specific information, EHAP used standard default values developed by ATSDR and EPA that are based on studies that measured:

- How much people weigh on average, and

- How much water people drink.

Appendix B contains detailed assumptions made in calculating doses and the rationale used to support them. Where there was uncertainty about default values, EHAP tried to overestimate exposure to be protective of health.

Cumulative Exposures

People are exposed daily to a diverse mixture of environmental stressors. An Health Consultation determines risk of harm from exposure to individual chemicals in a specific environmental medium. In this Health Consultation, EHAP was focused solely on exposures to COPCs from drinking the water in domestic wells. This Health Consultation does not consider chemical exposures from other sources or routes of exposure. EHAP does not have information on chemical exposures this community may have besides well water.

Conclusions

Conclusions are organized by contaminant. Contaminants are listed alphabetically with the more concerning conclusions presented at the beginning of a contaminant section. There are 13 conclusions overall, and conclusion numbering continues from contaminant to contaminant (i.e., numbering does not start over with each contaminant).

Conclusions related to arsenic

Conclusion 1: Children under 1 year-old who drink water from wells with arsenic levels over 35 µg/L for one day or more are at risk of facial swelling, nausea, vomiting, and diarrhea.

Basis for Conclusion 1: One well in the study had arsenic concentrations above 35 µg/L. Well water containing arsenic over 35 µg/L poses an acute risk to infants under 1 year-old who drink it, even for just a short time, as in a day or more. Formula-fed infants are at highest risk because they get the highest dose of arsenic.

Conclusion 2: Anyone who drinks water from wells with arsenic levels over 2 μg/L for a year or more is at increased risk of cancers of the skin, bladder, and lungs, as well as wart-like lesions and changes in the blood vessels of the skin.

Basis for Conclusion 2: In this well study, 51 out of 55 wells in the Fall of 2024 and 55 out of 58 wells in the Spring of 2025 had water with arsenic levels over 2 μg/L. While this concentration is below the public drinking water standard for arsenic (10 μg/L), it is high enough to increase cancer risk and increase the risk of non-cancer health effects of the skin if it is the primary drinking water source for a year or more. At the highest levels of arsenic measured in the study (38.6 μg/L), a person drinking it for a year or more is also at risk of more non-cancer health effects. Arsenic is a very common, naturally occurring contaminant in groundwater wells in Oregon.

Conclusion 3: Drinking well water with 2 μg/L or less of arsenic poses very low risk to anyone.

Basis for Conclusion 3: Four wells had arsenic below 2 μg/L in the Fall of 2024 and 3 wells had arsenic below 2 μg/L in the Spring of 2025 in this study. Arsenic at or below 2 μg/L in well water is too low to harm the health of anyone who drinks it.

Conclusions related to copper

Conclusion 4: Children under 1 year-old who drink well water with copper levels over 140 μg/L for 1 day or more are at increased risk of abdominal pain, nausea and vomiting.

Basis for Conclusion 4: One well in the study had copper levels over 140 μg/L. Copper is an essential nutrient, but at 140 μg/L in well water there is enough to cause acute symptoms in a child under 1 year-old, since that is the age group that would get the highest dose. High levels of copper in the short-term can irritate the lining of the digestive tract causing abdominal pain, nausea, and vomiting. Children older than 1 and adults are not at risk from any of the levels of copper measured in the study.

Copper in drinking water is often the result of leaching from piping or plumbing fixtures.

Conclusion 5: Drinking well water with copper levels at or below 140 µg/L is not expected to harm anyone's health.

Basis for Conclusion 5: Copper at or under 140 µg/L in water is too low to harm the health of anyone who drinks it. Children older than 1 year and adults are not at risk from any of the levels of copper measured in the study.

Conclusions related to fluoride

Conclusion 6: Fluoride levels in the wells tested in this study were too low to harm the health of anyone who drinks it.

Basis for Conclusion 6: The levels of fluoride measured in this study (maximum of 1,250 µg/L) were not high enough to harm health.

Conclusions related to lead

Conclusion 7: Test results showed elevated lead in some wells. People who drink water from wells containing detectable levels of lead for any amount of time are at increased risk of health effects. Children are at greatest risk because they get the highest dose of lead from the water and because their brains are in developmental stages that are sensitive to changes caused by lead.

Basis for Conclusion 7: There is no safe level of lead. In this well study, 26 wells had detectable levels of lead. The health effects associated with the lowest doses of lead are impaired brain development in people exposed as children leading to decreases in IQ and increases in the potential for neurobehavioral problems. These problems may persist long after the exposure to lead has ended.

The most common sources of lead in drinking water are plumbing, plumbing fixtures, and old well components.

Conclusions related to manganese

Conclusion 8: Children under 1 year of age who drink well water containing over 300 µg/L manganese for a year are at increased risk of neurobehavioral and cognitive problems.

Basis for Conclusion 8: Seven wells in this study had manganese levels over 300 µg/L. Manganese is an essential nutrient, but water with more than 300 µg/L can be too much for children under 1 year-old, which is the group that would get the highest dose from water. Children older than 1 year and adults are not at risk from manganese in drinking water even at the highest concentration measured in the study (464 µg/L).

Conclusion 9: Water with manganese levels over 50 µg/L may be unpleasant to use and drink for people of all ages.

Basis for Conclusion 9: Starting at 50 µg/L, manganese can cause black sedimentation, stain laundry, appear cloudy, and taste metallic and unpleasant. Water with levels between 50 and 300 µg/L manganese does not pose health risks to anyone but it is likely to be unpleasant to use for these aesthetic reasons. In this study, 27 wells had manganese levels between 50 and 300 µg/L.

Conclusions related to nitrate

Conclusion 10: Children under 6 years old who drink water with nitrate at 10 or more milligrams per liter (mg/L) for a day or more are at increased risk of methemoglobinemia, or blue-baby syndrome, which is reduced oxygen-carrying capacity of red blood cells. Women in the third trimester of pregnancy who drink water with 10 mg/L or more of nitrate may also be at increased risk of miscarriage. Anyone who drinks water with 10 mg/L or more of nitrate for 1 year or more may also be at increased risk of stomach cancer and thyroid problems.

Basis for Conclusion 10: Twelve wells in this study had nitrate over 10 mg/L. Nitrate over 10 mg/L in drinking water can decrease the capacity of red blood cells to carry oxygen throughout the body. Formula-fed infants are at highest risk because they get the highest dose of nitrate from drinking water. Formula-fed infants are also at highest risk because methemoglobinemia (blue-baby syndrome) can become acutely life threatening for them. Children 6 years and older and non-pregnant women are at much less risk from short-term exposures, but all ages may have increased risk of cancer and thyroid problems if they drink water with 10 mg/L or more of nitrate for a year or more.

Conclusion 11: Well water with nitrate between 5 and 10 mg/L does not pose health risks but is at risk of fluctuating above 10 mg/L at different times of year. In addition, boiling water during cooking, or for preparation of hot drinks, can increase (worsen) the nitrate concentration and increase the health risk.

Basis for Conclusion 11: This study found 13 wells with nitrate between 5 and 10 mg/L. Nitrate levels in this range in well water are too low to harm health, but above naturally-occurring levels, indicating that nitrate is entering the well from a local source. The most common sources are nearby livestock or other agricultural practices or failing septic systems. These inputs can change seasonally with different water table levels and surface runoff conditions. This means that nitrate levels between 5 and 10 mg/L in well water can fluctuate seasonally posing a risk that the well may have nitrate at or over 10 mg/L during some parts of the year or increase over the course of multiple years.

Conclusions related to total coliform

Conclusion 12: People who drink water from wells with detectable levels of total coliform for any amount of time are at increased risk of gastrointestinal symptoms like abdominal pain, nausea, vomiting, and diarrhea. Infants, young children, and people with compromised immune systems are at greatest risk.

Basis for Conclusion 12: In Fall of 2024, 13 wells in this study tested positive for total coliform. In Spring of 2025, only 4 wells tested positive for total coliform. Total coliform is a broad category of bacteria, and not all of them cause disease (are pathogenic). The laboratory retested samples from all wells that tested positive for total coliform to look for a specific pathogenic species of bacteria in the total coliform category called Escherichia coli (E. coli). None of the wells tested positive for E. coli, but finding total coliform indicates that bacteria are getting into some wells, and some of those could include illness-causing bacteria or E. coli in the future. The source of total coliform in well water is usually a break in the well seal, impacts from a septic system, or animals and/or animal waste near the well head.

Conclusions related to vanadium

Conclusion 13: Vanadium levels in the wells tested in this study were too low to harm the health of anyone who drinks it.

Basis for Conclusion 13: Vanadium is a metal that can increase blood pressure and cause other problems with the blood. The levels of vanadium measured in this study (maximum of 73.2 µg/L) were not high enough to harm health.

Recommendations

EHAP recommends that:

- **Everyone who uses a private domestic well for drinking water:**
    - Test their wells every 3 to 5 years for arsenic to monitor levels over time and after major events such as flooding or earthquakes.
    - Test their well at least annually for nitrate.
    - Test their well at least annually for total coliform and conduct follow up testing for E. coli if total coliform are found.
- EHAP recommends that well users use sampling results from their individual well to identify appropriate next steps based on the levels of contaminants in their well water as described below.

EHAP recommends that:

- People with **arsenic levels over 35 µg/L** in their well water:
    - Immediately find a safer alternative source of water for children under 1 year-old to consume, including for use in formula, because a short-term exposure above this level can cause acute risk to children under this age.
- People with **arsenic levels over 2 µg/L** in their well water:
    - Ensure treatment is in place or find an alternate source of water to drink, prepare beverages, and cook food to reduce the risk to health from long-term exposure.

- People with **copper levels over 140 µg/L** in their well water:
    - Immediately find a safer, alternate source of water for children under 1 year-old to consume, including for use in infant formula.
    - Confirm the test results and, if confirmed, seek treatment and evaluate whether copper in plumbing or plumbing fixtures is the source.
- People with **detectable levels of lead** in their well water:
    - Seek blood lead testing for all household members, especially children, from their healthcare providers.
    - Do additional water testing to determine whether the source of lead is the well itself or plumbing.
    - Run water long enough to flush out water that has been standing in lead-containing plumbing (usually 1-2 minutes) before collecting water to drink or use in beverages or cooking.
    - Consider replacing lead-containing plumbing, plumbing fixtures, or well components, especially if flushing is not effective at bringing down lead levels in tap water.
- People with **manganese levels over 300 µg/L** in their well water:
    - Ensure that treatment is in place or that an alternate source of water is available for children under 1 year-old to drink, including for use in infant formula.
- People with **manganese levels between 50 and 300 µg/L** in their well water:
    - Consider seeking treatment options to address aesthetic problems.
- People with **nitrate levels at or over 10 mg/L** in their well water:
    - Ensure that treatment is in place or immediately provide a safer alternative source of water for children under 6 years-old and women in the third trimester of pregnancy to drink, use in beverages, or cook.
    - Ensure treatment is in place or find a safer alternative source of water for all members of the household to use for drinking, making beverages, and cooking food over the long-term.

    - Identify and reduce or eliminate local sources of nitrate (e.g., nearby agriculture, livestock, or failing septic systems) and try to reduce nitrate infiltration into their well, including checking surface seals around the well to ensure seepage is not occurring along the well casing.
- People with **nitrate levels between 5 and 10 mg/L** in their well water:
    - Test their well water more frequently at different seasons of the year, particularly summer, to make sure nitrate is staying below 10 mg/L all year.
    - Consider looking for local sources of nitrate (e.g., nearby agriculture, livestock, or failing septic systems) and ways to reduce their infiltration into their well, including checking surface seals around the well to ensure seepage is not occurring along the well casing.
- People with **detected total coliform** in their well water:
    - Follow guidance available at and referenced by OHA's Domestic Well Safety Program's Well User Resource Toolkit (available at www.healthoregon.org/wells) to identify potential sources of bacterial contamination and disinfect the well.
    - Test again after disinfecting the well to make sure efforts to eliminate total coliform were successful.

Public Health Action Plan

A Public Health Action Plan describes the specific actions EHAP has taken and will take to implement the recommendations outlined in this report, to prevent and reduce people's exposure to hazardous substances in the environment. EHAP has been involved with public health related work at this site since late 2023. Crook County Commissioners convened a group of state agency representative to address groundwater quality issues raised by their constituents. EHAP was included in this group and collaborated with other state agencies and the local health department to plan a response.

Completed public health actions

To enable exposure prevention actions, EHAP:

- Created and distributed a suite of resources about domestic well maintenance and human health, including an official Crook County Wells webpage, OHA's Well Owners Handbook, and a YouTube video explaining OHA's Health Consultation process.
- Co-hosted a public open house to answer questions and provide resources to community members about how to protect their health.
- Provided individualized household consultation following availability of sampling results in Fall 2024 and Spring 2025
- Provided ongoing support and consultation to local public health and state environmental agencies

Planned future public health actions

EHAP will:

- Provide DEQ and other agencies with technical assistance in future sampling and other work done in the project area.
- Continue working with DEQ to review data if additional domestic well data become available.
- Continue to provide consultation to individual members of the community to provide health information related to well contaminants.
- Help community members find information about domestic well treatment options.
- Provide information about how to get blood lead levels tested for families with detectable levels of lead in their water.

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Appendix A. Screening Domestic Well Sample Results for Contaminants of Potential Concern

This appendix contains the summary statistics of domestic well testing results from Crook County wells. These tables only contain the analytes for which screening levels are available. EHAP already shared the complete set of results with individuals whose wells were tested. DEQ's report (4) also contains results for all analytes for all wells. Table A- 1 shows the results of the Fall 2024 sampling round and screens the results against the lowest of the aesthetics-based or health-based comparison value.

Table A- 1. Results for the first round of sampling in the Fall of 2024

Analyte	Detections out of 55 total samples	Minimum	Maximum	CV	Source of CV	Number of samples over CV (percent)	Contaminant of Potential Concern (Yes/No)
Anions and Cations (µg/L)							
Chloride	55	1,740	18,800	250,000	MCL-2	0 (0)	No
Fluoride	55	82.5	1,110	350	ATSDR	6 (11)	Yes
Sulfate	54	ND	36,100	250,000	MCL-2	0 (0)	No
Nitrogen Compounds (mg/L)							
Nitrate (as nitrogen)	37	ND	13.75	10	MCL	10 (18)	Yes
Total Metals (µg/L)							
Aluminum	16	ND	1,160	200	MCL-2	3 (5)	Yes
Arsenic	55	1.37	35.8	2	ATSDR	51 (93)	Yes

Analyte	Detections out of 55 total samples	Minimum	Maximum	CV	Source of CV	Number of samples over CV (percent)	Contaminant of Potential Concern (Yes/No)
Cadmium	2	ND	0.536	5	MCL	0 (0)	No
Chromium	8	ND	6.43	100	MCL	0 (0)	No
Cobalt	18	ND	1.51	140	ATSDR	0 (0)	No
Copper	42	ND	143	140	ATSDR	1 (2)	Yes
Iron	40	ND	2540	300	MCL-2	14 (25)	Yes
Lead	26	ND	47	ND	ATSDR	26 (47)	Yes
Lithium	4	ND	15	40	EPA RSL	0 (0)	No
Manganese	45	ND	409	50	MCL-2	28 (51)	Yes
Mercury	0	ND	0.07	2	MCL	0 (0)	No
Nickel	28	ND	3.17	140	ATSDR	0 (0)	No
Selenium	9	ND	2	50	MCL	0 (0)	No
Vanadium	39	ND	69.9	71	ATSDR	0 (0)	No
Zinc	40	ND	139	2,100	ATSDR	0 (0)	No
Bacteria (Detect/ND)							
E. coli	0	ND	0	ND	MCL	0 (0)	No
Total coliform	12	ND	DETECT	ND	MCL	12 (22)	Yes
Exported Friday, August 15, 2025 from PHAST version 2.5.1.0, database rev 8.5.22 CV = Comparison value; ATSDR = Agency for Toxic Substances and Disease Registry; MCL-2 = Secondary Maximum Contaminant Level; MCL = Primary Maximum Contaminant Level; EPA = Environmental Protection Agency; RSL = Regional Screening Level; ND = Not detected							

Table A- 2 shows results for the Spring 2025 round of well sampling and screens the results against the lowest of their aesthetics-based or health-based comparison values.

Table A- 2. Results for the second round of sampling in the Spring of 2025

Analyte	Detections out of 58 total samples	Minimum	Maximum	CV	Source of CV	Number of samples over CV (percent)	Contaminant of Potential Concern (Yes/No)
Anions and Cations (µg/L)							
Chloride	58	2020	39800	250000	MCL-2	0	No
Fluoride	58	115	1250	350	ATSDR	13 (22)	Yes
Sulfate	57	ND	45200	250000	MCL-2	0	No
Nitrogen Compounds (mg/L)							
Nitrate (as nitrogen)	38	ND	20.73	10	MCL	9 (15)	Yes
Total Metals (µg/L)							
Aluminum	19	ND	203	200	MCL-2	1 (2)	Yes
Arsenic	58	1.1	38.6	2	ATSDR	55 (95)	Yes
Cadmium	2	ND	2	5	MCL	0 (0)	No
Chromium	7	ND	1.56	100	MCL	0 (0)	No
Cobalt	14	ND	2	140	ATSDR	0 (0)	No
Copper	54	ND	130	140	ATSDR	0 (0)	No
Iron	38	ND	799	300	MCL-2	10 (17)	Yes
Lead	23	ND	37.6	ND	ATSDR	23 (40)	Yes
Lithium	24	ND	16.5	40	EPA RSL	0 (0)	No
Manganese	43	ND	464	50	MCL-2	32 (54)	Yes
Mercury	2	ND	0.0944	2	MCL	0 (0)	No
Nickel	26	ND	3.26	140	ATSDR	0 (0)	No
Selenium	9	ND	1.12	50	MCL	0 (0)	No

Analyte	Detections out of 58 total samples	Minimum	Maximum	CV	Source of CV	Number of samples over CV (percent)	Contaminant of Potential Concern (Yes/No)
Vanadium	37	ND	73.2	71	ATSDR	1 (2)	Yes
Zinc	48	ND	419	2100	ATSDR	0 (0)	No
Bacteria (Detect/ND)							
E. coli	0	ND	0	ND	MCL	0 (0)	No
Total coliform	4	ND	DETECT	ND	MCL	4 (7)	Yes
Exported Friday, August 15, 2025 from PHAST version 2.5.1.0, database rev 8.5.22 CV = Comparison value; ATSDR = Agency for Toxic Substances and Disease Registry; MCL-2 = Secondary Maximum Contaminant Level; MCL = Primary Maximum Contaminant Level; EPA = Environmental Protection Agency; RSL = Regional Screening Level; ND = Not detected							

Appendix B. Calculation of Risk from Drinking Well Water from the Most Contaminated Wells Tested in Crook County

Health risk from well contaminants across the sampling area varies depending on the concentration of contaminants in a particular well. To ensure health protection for all households, EHAP calculated maximum risk for the area by using the highest concentrations measured at any well within the sampling area. This appendix describes how EHAP calculated maximum/highest health risk for exposure to the highest measured concentration of each contaminant in any well within the sampling area. Overall, these risk results are not representative of any single well because no single well had all the maximum measured concentrations of all the contaminants.

EHAP used ATSDR's Public Health Assessment Site Tool (PHAST) for all dose and risk calculations but used a non-ATSDR health guideline value for calculation of risk from manganese. The health guideline value EHAP used for the manganese risk calculations was the EPA's oral reference dose (RfD), which was derived in a similar way to ATSDR's minimal risk levels (MRLs). EHAP used the EPA RfD for manganese because ATSDR does not have an MRL for manganese.

Equations

Water Ingestion Exposure Dose Equation

$D_{noncancer} = (C \times IR \times EF_{noncancer}) \div BW$ Equation 1

$D_{noncancer}$ = dose (mg/kg/day), C = contaminant concentration (mg/L), IR = intake rate (L/day), $EF_{noncancer}$ = exposure factor (unitless), BW = body weight (kg)

Hazard Quotient

$HQ = D_{noncancer} \div HG$ Equation 2

HQ = hazard quotient, $D_{noncancer}$ = dose (mg/kg/day), HG = health guideline (e.g., oral MRL, RfD)

Cancer Risk Equations

$CR = (D_{noncancer} \times CSF) \times (ED \div LY)$ for each exposure group Equation 3

ADAF-adjusted $CR = (D_{noncancer} \times CSF) \times (ED \div LY) \times ADAF$ for each exposure group Equation 4

Total CR = Sum of the CR for all exposure groups Equation 5

CR = cancer risk (unitless), $D_{noncancer}$ = dose, CSF = oral cancer slope factor [$(mg/kg/day)^{-1}$], EF (cancer) = exposure factor (cancer)
calculated as follows: EF (noncancer; unitless) x exposure group specific exposure duration (years) ÷ lifetime of 78 years,
ADAF = age-dependent adjustment factor (unitless), ED = exposure duration (years), LY = lifetime years (78 years)

Default Exposure Factors

Duration Category	Days per Week	Weeks per Year	Years	Exposure Group Specific EF noncancer	Exposure Group Specific* EF cancer
Acute	-	-	-	1	-
Intermediate	7	-	-	1	-
Chronic	7	52.14	See exposure group specific exposure durations	1	$= EF_{noncancer} \times (ED_{age\text{-}specific\ (yrs)} \div 78\ years)$

Abbreviations: EF = exposure factor; NC = not calculated
* Cancer risk is averaged over a lifetime of exposure (78 years).

Default Exposure Parameters

Exposure Group	Body Weight (kg)	CTE Exposure Duration (yrs)	CTE Intake Rate (liters/day)	RME Exposure Duration (yrs)	RME Intake Rate (liters/day)
Birth to < 1 year	7.8	1	0.595	1	1.106
1 to < 2 years	11.4	1	0.245	1	0.658
2 to < 6 years	17.4	4	0.337	4	0.852
6 to < 11 years	31.8	5	0.455	5	1.258
11 to < 16 years	56.8	1	0.562	5	1.761
16 to < 21 years	71.6	0	0.722	5	2.214
Total Child (all age groups)	-	12	-	21	-
Adult	80	12	1.313	33	3.229
Pregnant Women	73	-	1.158	-	2.935
Breastfeeding Women	73	-	1.495	-	3.061

Abbreviations: CTE = central tendency exposure (typical); kg = kilograms; RME = reasonable maximum exposure (higher)

Contaminant Information

Contaminant Name	Entered Concentration	EPC Type	Converted Concentration*
Arsenic	38.6 µg/L	Maximum	0.0386 mg/L
Copper	143 µg/L	Maximum	0.143 mg/L
Fluoride	1250 µg/L	Maximum	1.25 mg/L
Manganese	464 µg/L	Maximum	0.464 mg/L
Nitrate	91.212 mg/L[1]	Maximum	91.212 mg/L
Vanadium	73.2 µg/L	Maximum	0.0732 mg/L

Abbreviations: µg/L = micrograms per liter; EPC = exposure point concentration; mg/L = milligram chemical per liter water; mg/L = milligrams per liter

* Contaminant concentration converted to standard unit for calculating exposure.

[1]The entered value for nitrate was the maximum nitrate result (20.73 mg/L) multiplied by 4.4. This was to follow ATSDR guidance to convert nitrate measured as nitrogen to the nitrate only concentration. This renders the concentration to the same units and therefore comparable to ATSDR minimal risk level (MRL).

Drinking Water Ingestion Chronic (Default)

Arsenic

Table 1. Residential Default exposure doses for chronic exposure to arsenic in drinking water at 0.0386 mg/L along with noncancer hazard quotients and cancer risk estimates*

PHAST Public Health Assessment Site Tool Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	CTE Cancer Risk	CTE Exposure Duration (yrs)	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient	RME Cancer Risk	RME Exposure Duration (yrs)
Birth to < 1 year	0.0029	49 †	-	1	0.0055	91 †	-	1
1 to < 2 years	0.00083	14 †	-	1	0.0022	37 †	-	1
2 to < 6 years	0.00075	12 †	-	4	0.0019	32 †	-	4
6 to < 11 years	0.00055	9.2 †	-	5	0.0015	25 †	-	5
11 to < 16 years	0.00038	6.4 †	-	1	0.0012	20 †	-	5
16 to < 21 years	0.00039	6.5 †	-	0	0.0012	20 †	-	5
Total Child	-	-	4.1E-3 ‡	12	-	-	>6E-3 ‡	21
Adult	0.00063	11 †	3.1E-3 ‡	12	0.0016	26 †	>6E-3 ‡	33
Pregnant Women	0.00061	10 †	-	-	0.0016	26 †	-	-
Breastfeeding Women	0.00079	13 †	-	-	0.0016	27 †	-	-
Birth to < 21 years plus 12 years during adulthood §	-	-	-	-	-	-	>6E-3 ‡	33

Source: Oregon Department of Environmental Quality was the source of the well testing data

Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher); yrs = years

* The calculations in this table were generated using ATSDR's PHAST v2.5.1.0. The noncancer hazard quotients were calculated using the chronic (lifetime) reference dose of 6E-05 mg/kg/day and the cancer risks were calculated using the cancer slope factor of 32 $(mg/kg/day)^{-1}$.

† Indicates the hazard quotient is greater than 1, which ATSDR evaluates further.

‡ EHAP used the linear slope factor from IRIS to calculate cancer risk from arsenic exposure. The resulting cancer risk is greater than 6E-3, which is a concern for increased cancer risk. EPA's toxicological review (22) states that the linear slope factor is not accurate at lifetime doses greater than 0.2 μg/kg/day, which equates to a cancer risk of 6E-3. Because the cancer risk is so high, the exact risk level is not needed to determine that the exposure is a concern.

§ This cancer risk represents a scenario where children are likely to continue to live in their childhood home as adults.

Fluoride

Table 2. Residential Default exposure doses for chronic exposure to fluoride in drinking water at 1.25 mg/L along with noncancer hazard quotients*

PHAST Public Health Assessment Site Tool Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	CTE Cancer Risk	CTE Exposure Duration (yrs)	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient	RME Cancer Risk	RME Exposure Duration (yrs)
Birth to < 1 year	0.095	1.9 †	-	1	0.18	3.5 †	-	1
1 to < 2 years	0.027	0.54	-	1	0.072	1.4 †	-	1
2 to < 6 years	0.024	0.48	-	4	0.061	1.2 †	-	4
6 to < 11 years	0.018	0.36	-	5	0.049	0.99	-	5
11 to < 16 years	0.012	0.25	-	1	0.039	0.78	-	5
16 to < 21 years	0.013	0.25	-	0	0.039	0.77	-	5
Total Child	-	-	-	12	-	-	-	21
Adult	0.021	0.41	-	12	0.050	1.0 †	-	33
Pregnant Women	0.020	0.40	-	-	0.050	1.0 †	-	-
Breastfeeding Women	0.026	0.51	-	-	0.052	1.0 †	-	-

Source: Oregon Department of Environmental Quality was the source of the well testing data

Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher); yrs = years

* The calculations in this table were generated using ATSDR's PHAST v2.5.1.0. The noncancer hazard quotients were calculated using the chronic (greater than 1 year) minimal risk level of 0.05 mg/kg/day.

† Indicates the hazard quotient is greater than 1, which ATSDR evaluates further.

Manganese

Table 3. Residential Default exposure doses for chronic exposure to manganese in drinking water at 0.464 mg/L*

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	CTE Cancer Risk	CTE Exposure Duration (yrs)	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient	RME Cancer Risk	RME Exposure Duration (yrs)
Birth to < 1 year	0.035	0.74	-	1	0.066	1.4†	-	1
1 to < 2 years	0.010	0.21	-	1	0.027	0.57	-	1
2 to < 6 years	0.0090	0.19	-	4	0.023	0.49	-	4
6 to < 11 years	0.0066	0.14	-	5	0.018	0.38	-	5
11 to < 16 years	0.0046	0.098	-	1	0.014	0.30	-	5
16 to < 21 years	0.0047	0.1	-	0	0.014	0.30	-	5
Total Child	-	-	-	12	-	-	-	21
Adult	0.0076	0.16	-	12	0.019	0.40	-	33
Pregnant Women	0.0074	0.16	-	-	0.019	0.40	-	-
Breastfeeding Women	0.0095	0.20	-	-	0.019	0.40	-	-

Source: Oregon Department of Environmental Quality was the source of the well testing data

Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher); yrs = years

* The calculations in this table were generated using ATSDR's PHAST v2.5.1.0. The noncancer hazard quotients were calculated using the chronic (greater than 1 year) reference dose of 0.047 mg/kg/day.

† Indicates the hazard quotient is greater than 1, which ATSDR evaluates further.

Nitrate

Table 4. Residential Default exposure doses for chronic exposure to nitrate in drinking water at 91.212¥ mg/L along with noncancer hazard quotients*

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	CTE Cancer Risk	CTE Exposure Duration (yrs)	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient	RME Cancer Risk	RME Exposure Duration (yrs)
Birth to < 1 year	7.0	1.7 †	-	1	13	3.2 †	-	1
1 to < 2 years	2.0	0.49	-	1	5.3	1.3 †	-	1
2 to < 6 years	1.8	0.44	-	4	4.5	1.1 †	-	4
6 to < 11 years	1.3	0.33	-	5	3.6	0.90	-	5
11 to < 16 years	0.90	0.23	-	1	2.8	0.71	-	5
16 to < 21 years	0.92	0.23	-	0	2.8	0.71	-	5
Total Child	-	-	-	12	-	-	-	21
Adult	1.5	0.37	-	12	3.7	0.92	-	33
Pregnant Women	1.4	0.36	-	-	3.7	0.92	-	-
Breastfeeding Women	1.9	0.47	-	-	3.8	0.96	-	-

Source: Oregon Department of Environmental Quality was the source of the well testing data

Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher); yrs = years

¥EHAP followed ATSDR guidance to adjust the maximum measured concentration of nitrate measured as nitrogen of (20.73 mg/L) to the molecular weight equivalent in nitrate. This is done by multiplying the measured "nitrate-N" concentration by the ratio of the molecular weight of nitrate to the molecular weight of nitrogen (4.4). So 20.73 mg/L nitrate-N times 4.4 equals 91.212 mg/L.

* The calculations in this table were generated using ATSDR's PHAST v2.5.1.0. The noncancer hazard quotients were calculated using the chronic (greater than 1 year) minimal risk level of 4 mg/kg/day.

† Indicates the hazard quotient is greater than 1, which ATSDR evaluates further.

Copper

Table 5. Residential Default exposure doses for intermediate exposure to copper in drinking water at 0.143 mg/L along with noncancer hazard quotients*

PHAST Public Health Assessment Site Tool Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
Birth to < 1 year	0.011	0.55	0.020	1.0 †
1 to < 2 years	0.0031	0.15	0.0083	0.41
2 to < 6 years	0.0028	0.14	0.0070	0.35
6 to < 11 years	0.0020	0.10	0.0057	0.28
11 to < 16 years	0.0014	0.071	0.0044	0.22
16 to < 21 years	0.0014	0.072	0.0044	0.22
Adult	0.0023	0.12	0.0058	0.29
Pregnant Women	0.0023	0.11	0.0057	0.29
Breastfeeding Women	0.0029	0.15	0.0060	0.30

Source: Oregon Department of Environmental Quality was the source of the well testing data
Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher)
* The calculations in this table were generated using ATSDR's PHAST v2.5.1.0. The noncancer hazard quotients were calculated using the intermediate (two weeks to less than 1 year) minimal risk level of 0.02 mg/kg/day.
† Indicates the hazard quotient is greater than 1, which ATSDR evaluates further.

Nitrate

Table 6. Residential Default exposure doses for intermediate exposure to nitrate in drinking water at 91.212¥ mg/L along with noncancer hazard quotients*

PHAST Public Health Assessment Site Tool Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
Birth to < 1 year	7.0	1.7 †	13	3.2 †
1 to < 2 years	2.0	0.49	5.3	1.3 †
2 to < 6 years	1.8	0.44	4.5	1.1 †
6 to < 11 years	1.3	0.33	3.6	0.90
11 to < 16 years	0.90	0.23	2.8	0.71
16 to < 21 years	0.92	0.23	2.8	0.71
Adult	1.5	0.37	3.7	0.92
Pregnant Women	1.4	0.36	3.7	0.92
Breastfeeding Women	1.9	0.47	3.8	0.96

Source: Oregon Department of Environmental Quality was the source of the well testing data
Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher)
¥EHAP followed ATSDR guidance to adjust the maximum measured concentration of nitrate measured as nitrogen of (20.73 mg/L) to the molecular weight equivalent in nitrate. This is done by multiplying the measured "nitrate-N" concentration by the ratio of the molecular weight of nitrate to the molecular weight of nitrogen (4.4). So 20.73 mg/L nitrate-N times 4.4 equals 91.212 mg/L.
* The calculations in this table were generated using ATSDR's PHAST v2.5.1.0. The noncancer hazard quotients were calculated using the intermediate (two weeks to less than 1 year) minimal risk level of 4 mg/kg/day.
† Indicates the hazard quotient is greater than 1, which ATSDR evaluates further.

Vanadium
Table 7. Residential Default exposure doses for intermediate exposure to vanadium in drinking water at 0.0732 mg/L along with noncancer hazard quotients*

PHAST Public Health Assessment Site Tool Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
Birth to < 1 year	0.0056	0.56	0.010	1.0 †
1 to < 2 years	0.0016	0.16	0.0042	0.42
2 to < 6 years	0.0014	0.14	0.0036	0.36
6 to < 11 years	0.0010	0.10	0.0029	0.29
11 to < 16 years	0.00072	0.072	0.0023	0.23
16 to < 21 years	0.00074	0.074	0.0023	0.23
Adult	0.0012	0.12	0.0030	0.30
Pregnant Women	0.0012	0.12	0.0029	0.29
Breastfeeding Women	0.0015	0.15	0.0031	0.31

Source: Oregon Department of Environmental Quality was the source of the well testing data
Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher)
* The calculations in this table were generated using ATSDR's PHAST v2.5.1.0. The noncancer hazard quotients were calculated using the intermediate (two weeks to less than 1 year) minimal risk level of 0.01 mg/kg/day.
† Indicates the hazard quotient is greater than 1, which ATSDR evaluates further.

Drinking Water Ingestion Acute (Default)
Arsenic
Table 8. Residential Default exposure doses for acute exposure to arsenic in drinking water at 0.0386 mg/L along with noncancer hazard quotients*

PUBLIC HEALTH ASSESSMENT SITE TOOL PHAST Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
Birth to < 1 year	0.0029	0.59	0.0055	1.1 †
1 to < 2 years	0.00083	0.17	0.0022	0.45
2 to < 6 years	0.00075	0.15	0.0019	0.38
6 to < 11 years	0.00055	0.11	0.0015	0.31
11 to < 16 years	0.00038	0.076	0.0012	0.24
16 to < 21 years	0.00039	0.078	0.0012	0.24
Adult	0.00063	0.13	0.0016	0.31
Pregnant Women	0.00061	0.12	0.0016	0.31
Breastfeeding Women	0.00079	0.16	0.0016	0.32

Source: Oregon Department of Environmental Quality was the source of the well testing data
Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher)
* The calculations in this table were generated using ATSDR's PHAST v2.5.1.0. The noncancer hazard quotients were calculated using the acute (less than two weeks) minimal risk level of 0.005 mg/kg/day.
† Indicates the hazard quotient is greater than 1, which ATSDR evaluates further.

Copper

Table 9. Residential Default exposure doses for acute exposure to copper in drinking water at 0.143 mg/L along with noncancer hazard quotients*

PUBLIC HEALTH ASSESSMENT SITE TOOL PHAST Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
Birth to < 1 year	0.011	0.55	0.020	1.0 †
1 to < 2 years	0.0031	0.15	0.0083	0.41
2 to < 6 years	0.0028	0.14	0.0070	0.35
6 to < 11 years	0.0020	0.10	0.0057	0.28
11 to < 16 years	0.0014	0.071	0.0044	0.22
16 to < 21 years	0.0014	0.072	0.0044	0.22
Adult	0.0023	0.12	0.0058	0.29
Pregnant Women	0.0023	0.11	0.0057	0.29
Breastfeeding Women	0.0029	0.15	0.0060	0.30

Source: Oregon Department of Environmental Quality was the source of the well testing data
Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher)
* The calculations in this table were generated using ATSDR's PHAST v2.5.1.0. The noncancer hazard quotients were calculated using the acute (less than two weeks) minimal risk level of 0.02 mg/kg/day.
† Indicates the hazard quotient is greater than 1, which ATSDR evaluates further.

Nitrate

Table 10. Residential Default exposure doses for acute exposure to nitrate in drinking water at 91.212[¥] mg/L along with noncancer hazard quotients*

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
Birth to < 1 year	7.0	1.7 †	13	3.2 †
1 to < 2 years	2.0	0.49	5.3	1.3 †
2 to < 6 years	1.8	0.44	4.5	1.1 †
6 to < 11 years	1.3	0.33	3.6	0.90
11 to < 16 years	0.90	0.23	2.8	0.71
16 to < 21 years	0.92	0.23	2.8	0.71
Adult	1.5	0.37	3.7	0.92
Pregnant Women	1.4	0.36	3.7	0.92
Breastfeeding Women	1.9	0.47	3.8	0.96

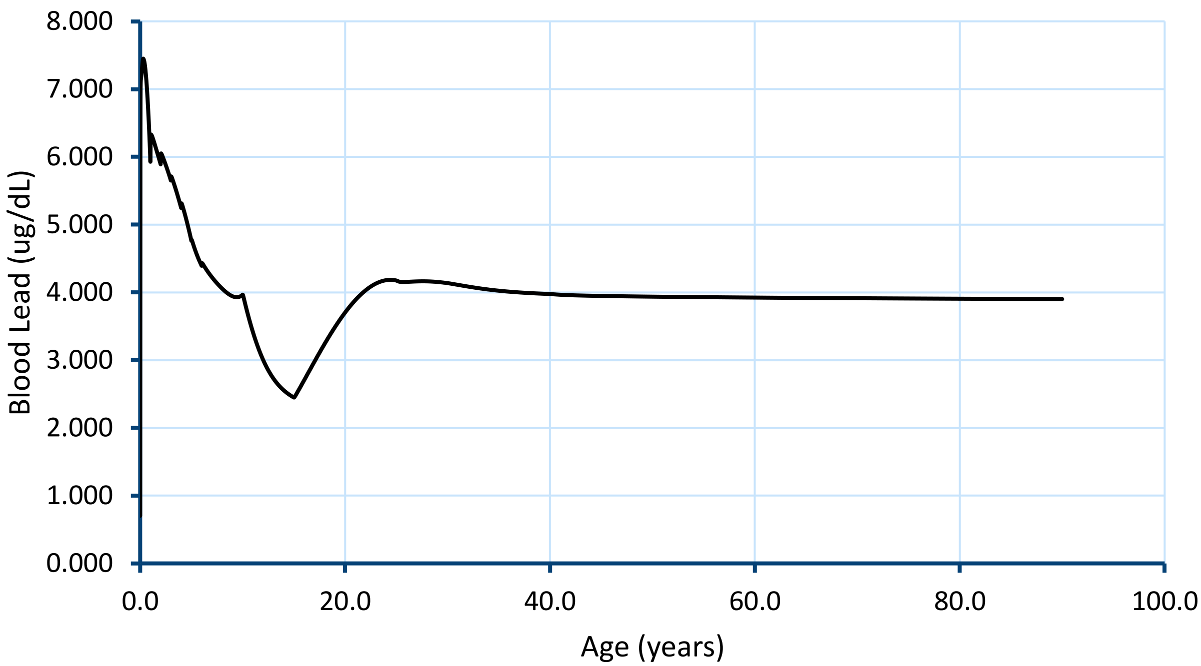
Source: Oregon Department of Environmental Quality was the source of the well testing data
Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher)
¥EHAP followed ATSDR guidance to adjust the maximum measured concentration of nitrate measured as nitrogen of (20.73 µg/L) to the molecular weight equivalent in nitrate. This is done by multiplying the measured “nitrate-N” concentration by the ratio of the molecular weight of nitrate to the molecular weight of nitrogen (4.4). So 20.73 µg/L nitrate-N times 4.4 equals 91.212 mg/L.
* The calculations in this table were generated using ATSDR’s PHAST v2.5.1.0. The noncancer hazard quotients were calculated using the acute (less than two weeks) minimal risk level of 4 mg/kg/day.
† Indicates the hazard quotient is greater than 1, which ATSDR evaluates further.

Appendix C: Lead Modeling

This appendix describes the mathematical models that EHAP followed to calculate the chances that children drinking water with lead would have elevated blood lead levels. EHAP used the EPA's All Ages Lead Model version 3.1 (AALMv3.1). (26)

Figure C- 1 shows estimated blood lead levels (BLL) from drinking the water with 47 µg/L lead over a 90-year lifetime. The childhood BLL at which state and county public health departments would pursue a follow-up investigation to identify the source of exposure is 3.5 µg/dL.

Figure C- 1. Estimated blood lead levels over a lifetime from drinking water with 47 µg/L lead



When running this model, EHAP used the default values recommended by the EPA for all media except soil and water. For soil, EHAP used the background soil concentration of lead for this region of the state (Blue Mountain Region) established by DEQ, which is 21 mg/kg. For water, EHAP used the highest concentration of lead measured in any well in this study, which was 47 µg/L.

Appendix D: Health Effects of Contaminants of Potential Concern

The summaries in this appendix are general and not specific to the exposure conditions described in the body of this Health Consultation. Many health effects described in these sections would only occur at doses much higher than would be possible from well water evaluated in this Health Consultation. Some of the effects below would also only occur if the exposure were via inhalation as from an occupational, industrial or traffic-related source. For the health effects relevant to exposures from well water evaluated in this Health Consultation, see the “In-depth analysis” section of the main report (page 42).

Arsenic

Arsenic is a naturally occurring element widely distributed in the earth's crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in animals and plants combines with carbon and hydrogen to form organic arsenic compounds. Inorganic arsenic compounds are mainly used to preserve wood. Breathing high levels of inorganic arsenic can give you a sore throat or irritated lungs. Ingesting high levels of inorganic arsenic can result in death. Lower levels of arsenic can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet. Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso. Skin contact with inorganic arsenic may cause redness and swelling (30).

Organic arsenic compounds are used as pesticides, primarily on cotton plants. Organic arsenic compounds are less toxic than inorganic arsenic compounds. Exposure to high levels of some organic arsenic compounds may cause similar effects as those caused by inorganic arsenic. Several studies have shown that inorganic arsenic can increase the risk of lung cancer, skin cancer, bladder cancer, liver cancer, kidney cancer, and prostate cancer. The United States Department of Health and Human Services (USDHHS), and the EPA have determined that inorganic arsenic is a human carcinogen (30).

People may be exposed to arsenic by ingesting small amounts present in food and water or breathing air containing arsenic, breathing sawdust or burning smoke from wood treated with arsenic, living in areas with unusually high natural levels of arsenic in rock, and/or working in a job that involves arsenic production or use, such as copper or lead smelting, wood treating, or pesticide application (30).

Breathing high levels of inorganic arsenic can give you a sore throat or irritated lungs. Ingesting very high levels of arsenic can result in death. Exposure to lower levels can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of “pins and needles” in hands and feet. Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small “corns” or “warts” on the palms, soles, and torso. Skin contact with inorganic arsenic may cause redness and swelling. Almost nothing is known regarding health effects of organic arsenic compounds in humans. Studies in animals show that some simple organic arsenic compounds are less toxic than inorganic forms. Ingestion of methyl and dimethyl compounds can cause diarrhea and damage to the kidneys (30).

Several studies have shown that ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. Inhalation of inorganic arsenic can cause increased risk of lung cancer. The Department of Health and Human Services (DHHS) and the EPA have determined that inorganic arsenic is a known human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans (30).

Copper Compounds

Copper (Cu) is an element and metal. It is found in rocks, soils, water, and air. Copper is an essential nutrient for humans and is in many foods. It is also essential to animals and plants. Copper and substances containing copper are used in many industries in the United States. Copper can be found in materials and products such as wiring, plumbing, pesticides, cookware, and dietary supplements, among others. Copper scrap can be combined with other metals to make brass and bronze pipes. In the United States, copper is mined and recovered from metal through smelting (31).

Copper is released from natural sources, such as windblown dusts and decaying vegetation, and from human activities like municipal solid waste management and fossil fuel burning. In air, copper usually attaches to particles (particulate matter) and can travel far from its source. In water, copper will usually attach to soils if possible, or dissolve. Copper attaches to soils, where it can be taken up by plants. Mollusks, such as clams and oysters, can build up copper in their bodies. Copper does not break down in the environment (31).

People can be exposed to copper by ingesting drinking water or food that contain copper, inhaling copper from air, and/or touching products that contain copper. Drinking water can contain high levels of copper if your home has copper pipes and acidic water. This is more likely to occur in new or recently renovated buildings/homes using copper plumbing. Blue copper sulfate crystals can be used to control algae in ponds and have been accidentally ingested by people who confused them for candy or toys. You may be exposed to copper particles in air if you work or live near a site that uses copper in mining or agriculture or in a facility that processes copper. Soils near mines, processing facilities, or waste dump sites may have a lot of copper (31).

Copper is essential for people to ingest small amounts of copper every day in food and water. Ingesting too much or too little copper can lead to illness and/or disease. Ingesting a high amount of copper, usually in drinking water, can cause vomiting, nausea, abdominal pain, and/or diarrhea. Ingesting higher than recommended amounts of copper every day over time, such as in water or in copper supplements, can lead to severe illness, such as kidney and liver damage. Breathing in copper dusts, sprays, or crystals can irritate your nose and throat and cause dizziness and headaches. People who have ingested these substances have gotten very sick and/or died. Copper is essential to the development of babies and children and is found in breast milk. Babies and children are expected to have symptoms similar to adults when exposed to high levels of copper in air, water, or food. If you have a disorder that causes copper to build up in your body, like Wilson's disease, you may be especially vulnerable to high copper levels in air, food, or water (31).

Fluoride

Fluorides are naturally occurring compounds. Low levels of fluorides can help prevent dental cavities. At high levels, fluorides can result in tooth and bone damage.

Hydrogen fluoride and fluorine are naturally-occurring gases that are very irritating to the skin, eyes, and respiratory tract. Fluorides, hydrogen fluoride, and fluorine are chemically related. Fluorine is a naturally-occurring, pale yellow-green gas with a sharp odor. It combines with metals to make fluorides such as sodium fluoride and calcium fluoride, both white solids. Sodium fluoride dissolves easily in water, but calcium fluoride does not. Fluorine also combines with hydrogen to make hydrogen fluoride, a colorless gas. Hydrogen fluoride dissolves in water to form hydrofluoric acid. Fluorine and hydrogen fluoride are used to make certain chemical compounds (32). Hydrofluoric acid is used for etching glass. Other fluoride compounds are used in making steel, chemicals, ceramics, lubricants, dyes, plastics, and pesticides. Fluorides are often added to drinking water supplies and to a variety of dental products, including toothpaste and mouth rinses, to prevent dental cavities.

Fluorine cannot be destroyed in the environment; it can only change its form. Fluorine forms salts with minerals in soil. Hydrogen fluoride gas will be absorbed by rain and into clouds and fog to form hydrofluoric acid, which will fall to the ground. Fluorides released to the air from volcanoes and industry re carried by wind and rain to nearby water, soil, and food sources. Fluorides in water and soil will form strong associations with sediment or soil particles. Fluorides will accumulate in plants and animals. In animals, the fluoride accumulates primarily in the bones or shell rather than in soft tissues (32).

The general population can be exposed to fluorides in contaminated air, food, drinking water and soil. People living in communities with fluoridated water or high levels of naturally-occurring fluoride may be exposed to higher levels. People who work or live near industries where fluoride-containing substances are used may be exposed to higher levels. Small amounts of fluoride help prevent tooth cavities, but high levels can harm your health. In adults, exposure to high levels of fluoride can result in denser bones. However, if exposure is high enough, these bones may be more fragile and brittle and there may be a greater risk of breaking the bone. In animals, exposure to extremely high doses of fluoride can result in decreased fertility and sperm and testes damage (32).

Lead

Lead is a metal found naturally in the earth's crust. It can be found in all parts of our environment, including air, water, and soil. Lead can combine with other chemicals to make different compounds. Lead is used in the production of batteries, ammunition, and metal products (solder and pipes). Because of health concerns, the use of lead in paints, ceramic products, caulking, and pipe solder has been dramatically reduced. The use of lead as an additive to automobile gasoline was banned in 1996 in the United States (33).

Adults and children may be exposed to lead by eating food or drinking water that contains lead, hand-to-mouth contact in inhalation after exposure to soil or dust that contains lead. Most exposure to lead (and the health effects that can follow) comes from accidental ingestion rather than skin exposure. Environmental exposure to lead has long been recognized as a public health problem, particularly among children (33).

The effects of lead are the same whether it enters the body by breathing it in or eating it. Lead can affect almost every organ and system in your body. The nervous system is the main target for lead poisoning in children and adults. Long-term exposure can result in decreased learning, memory, and attention, and weakness in fingers, wrists, or ankles. Lead exposure can cause anemia (low iron in the blood) and damage to the kidneys. It can also cause increases in blood pressure, particularly in middle-aged and older individuals. Exposure to high lead levels can severely damage the brain and kidneys and can cause death. In pregnant women, exposure to high levels of lead may cause a miscarriage. In men, it can cause damage to reproductive organs (33).

High levels of lead in soil have been shown to increase blood lead levels in young children. Children can be exposed from eating lead-based paint chips or playing in contaminated soil. Lead can damage the nervous system, kidneys, and reproductive system. Signs and symptoms associated with lead toxicity include:

- Decreased learning capacity and memory
- Lowered Intelligence Quotient (IQ)
- Speech and hearing impairments
- Fatigue and lethargy.

Protecting children from exposure to lead is important to their lifelong good health. No safe blood lead level in children has been identified. Even low blood lead levels have been shown to affect IQ, ability to pay attention, and academic achievement (33).

Manganese

Manganese is a naturally occurring metal that is found in many types of rocks. Pure manganese is silver colored, but does not occur naturally. It combines with other substances such as oxygen, sulfur, or chlorine. Manganese occurs naturally in most foods and may be added to some foods. Manganese is used principally in steel production to improve hardness, stiffness, and strength. It may also be used as an additive in gasoline to improve the octane rating of the gas (34).

Manganese can be released to the air, soil, and water from the manufacture, use, and disposal of manganese-based products. Manganese cannot break down in the environment. It can only change its form or become attached to or separated from particles. In water, manganese tends to attach to particles in the water or settle into the sediment. The chemical state of manganese and the type of soil determine how fast it moves through the soil and how much is retained in the soil. The manganese-containing gasoline additive may degrade in the environment quickly when exposed to sunlight, releasing manganese (34).

The primary way people can be exposed to manganese is by eating food or manganese-containing nutritional supplements. Vegetarians, who consume foods rich in manganese such as grains, beans and nuts, as well as heavy tea drinkers, may have a higher intake of manganese than the average person. Certain occupations like welding or working in a factory where steel is made may increase your chances of being exposed to high levels of manganese. Manganese is routinely contained in groundwater, drinking water, and soil at low levels. Drinking water containing manganese or swimming or bathing in water containing manganese may expose you to low levels of this chemical (34).

Manganese is an essential nutrient, and eating a small amount of it each day is important to stay healthy. The most common health problems in workers exposed to high levels of manganese involve the nervous system. These health effects include behavioral changes and other nervous system effects, which include movements that may become slow and clumsy. This combination of symptoms when sufficiently severe is referred to as “manganism”. Other less severe nervous system effects such as slowed hand movements have been observed in some workers exposed to lower concentrations in the work place (34).

Nitrate

Nitrate and nitrite are two nitrogen compounds that are needed by plants and animals to live and grow. They occur naturally in soil, water, and air. Nitrate and nitrite are also made in the body. In industry, the majority of nitrate is used as fertilizers for crops or lawns. Nitrate and nitrite are also used in food preservation, some pharmaceutical drugs, and in the production of munitions and explosives (35).

Nitrate and nitrite are naturally present in soils, water, air, and plants. The use of fertilizers and waste from animals adds to the amount of nitrate in the environment. Nitrate and nitrite dissolve easily in water and will therefore move quickly through the soil into surface water and groundwater. In the soil and water, these chemicals will usually remain until taken up by plants or changed into another chemical (such as nitrogen) by microorganisms. Nitrate and nitrite do not evaporate into the air (35).

Nitrate and nitrite are found in diets through vegetables (especially celery, lettuce, and spinach), fruits, cured meats, fish, dairy products, beers, and cereals. Some meats and meat products contain sodium nitrate and/or sodium nitrite as preservatives. In addition, your body naturally makes these chemicals. Drinking water from wells containing nitrate from sources such as animal waste and/or fertilizer runoff and eating plants grown in contaminated soil will increase your exposure to these chemicals (35).

Most people are not exposed to levels that would cause health problems. Some people who ate food or drank fluids that contained unusually high levels of nitrite experienced methemoglobinemia (decreased ability of the blood to carry oxygen to tissues). This was also seen in young infants (<6 months of age) who drank formula made with water having higher than recommended nitrate at levels. Symptoms people experienced included decreased blood pressure, increased heart rate, headaches, abdominal cramps, and vomiting; some people died. In animal studies, changes in thyroid function were seen in rats that were fed or drank high levels of nitrate or nitrite (35).

Vanadium

Vanadium is an element that occurs in nature as a white-to-gray metal compounds, and is often found as crystals. Pure vanadium has no smell. It usually combines with other elements such as oxygen, sodium, sulfur, or chloride. Vanadium and vanadium compounds can be found in the earth's crust and in rocks, some iron ores, and crude petroleum deposits. Vanadium is used in producing rust-resistant, spring, and high-speed tool steels. Vanadium pentoxide is used in ceramics, as a catalyst, and in the production of superconductive magnets. Vanadyl sulfate and sodium metavanadate have been used as dietary supplements (36).

Vanadium mainly enters the environment from natural sources and from the burning of fuel oils. It does not dissolve well in water. It combines with other elements and particles. Vanadium binds strongly to soil and sediments. Low levels have been found in plants, but it is not likely to build up in the tissues of animals (36).

People can be exposed to vanadium by eating foods that contain vanadium (higher levels are found in seafoods), breathing air near an industry that burns fuel oil or coal (these industries release vanadium oxide into the air), or working in industries that process vanadium or make products containing vanadium. People can also be exposed by breathing contaminated air or drinking contaminated water near waste sites or landfills containing vanadium or by breathing cigarette smoke. Vanadium is found in some nutritional supplements (36).

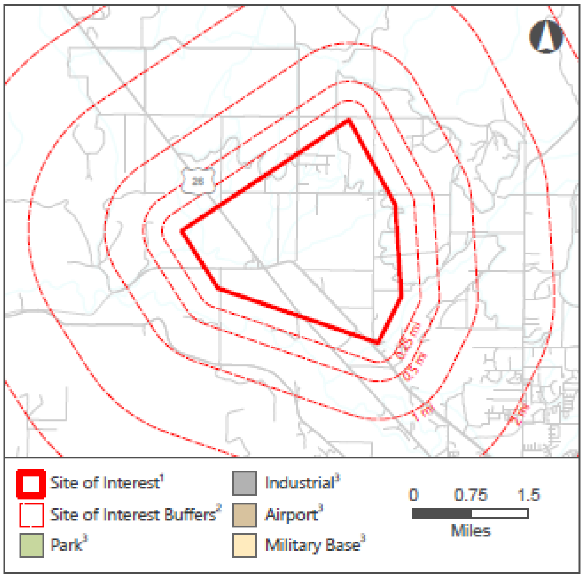
Vanadium is not readily absorbed by the body from the stomach, gut, or contact with the skin. Exposure to high levels of vanadium pentoxide in air can result in lung damage. Nausea, mild diarrhea, and stomach cramps have been reported in people some vanadium compounds. A number of effects have been found in animals ingesting vanadium compounds including decreases in the number of red blood cells, increased blood pressure, and mild neurological effects. The amounts of vanadium given in these animal studies that resulted in harmful effects are much higher than those likely to occur in the environment (36).

Appendix E: General Site Profile Map

Crook County Domestic Well Sampling Area
Prineville, Crook County, OR

INTRODUCTORY MAP SERIES
GENERAL SITE PROFILE

Site Vicinity Map

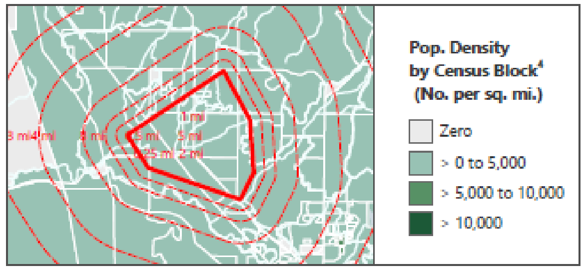


The **General Site Profile Map** depicts the hazardous waste site of interest, along with any airport, industrial, military, or park land uses. It also provides community demographic and housing statistics.

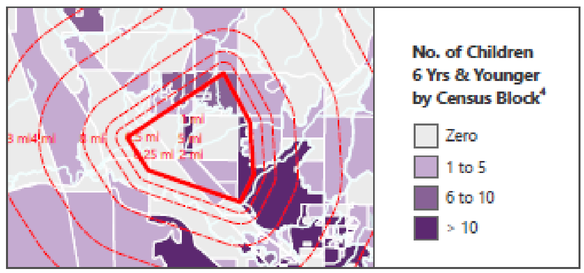
Demographic Statistics[4,5]
Within 1 Miles buffer of site boundary

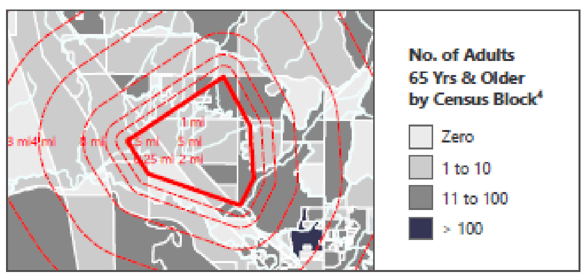
Measure	2010	2020	Change
Total Population	891	1,010	+13%
White Alone	867	901	+3%
Black Alone	1	2	+100%
Am. Indian/Alaska Native Alone	5	25	+400%
Asian Alone	0	3	N/A
Native Hawaiian & Other Pacific Islander Alone	0	1	N/A
Some Other Race Alone	5	9	+80%
Two or More Races	13	68	+423%
Hispanic or Latino[6]	26	43	+65%
Children Aged 6 and Younger	54	81	+50%
Adults Aged 65 and Older	173	226	+30%
Females Aged 15 to 44	128	137	+7%
Housing Units	380	384	+1%
Housing Units Pre 1950	38	48	+26%

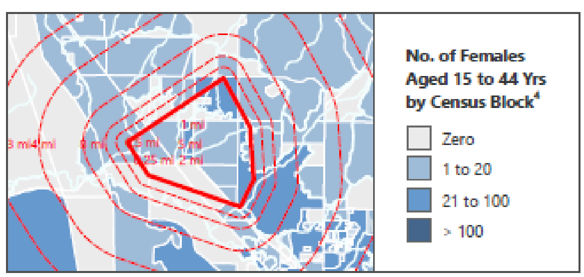
General Population Density



Sensitive Populations







Data Sources: [1]Oregon Health Authority, [2]ATSDR GRASP, [3]TomTom 2021Q3, [4]US Census 2020 Demographic and Housing Characteristics, **Notes:** [5]Calculated using area-proportion spatial analysis method, [6]Individuals identifying origin as Hispanic or Latino may be of any race. **Coordinate System:** Coordinate System used for all map panels is NAD 1983 StatePlane Oregon South FIPS 3602 Feet

ATSDR Agency for Toxic Substances and Disease Registry

GRASP Geospatial Research, Analysis, and Services Program

PRJ ID 16817 | **AUTHOR** Nina Dutton

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1/20/2026

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