Health Consultation

Van Stone Mine, Evaluation of Environmental Exposures
Colville, Stevens County, Washington

September 15, 2014

Prepared by

The Washington State Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Washington State Department of Health

DOH 334-358 September 2014

Foreword

The Washington State Department of Health (DOH) prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services. ATSDR is responsible for health issues related to hazardous substances.

The purpose of a health consultation is to assess the health threat posed by hazardous substances in the environment. If needed, a health consultation will also recommend steps or actions to protect public health. Health consultations are initiated in response to health concerns raised by residents or agencies about exposure to hazardous substances.

This health consultation was prepared in accordance with ATSDR methodologies and guidelines. However, the report has not been reviewed and cleared by ATSDR. Findings in this report are relevant to conditions at the site during the time the report was written. It should not be relied upon if site conditions or land use changes in the future.

Use of trade names is for identification only and does not imply endorsement by state or federal health agencies.

For additional information, please contact us at 1-877-485-7316 or visit our web site at www.doh.wa.gov/consults.

For persons with disabilities this document is available on request in other formats. To submit a request, please call 1-800-525-0127 (TDD/TTY call 711).

For more information about ATSDR, contact the CDC Information Center at 1-800-CDC-INFO (1-800-232-4636) or visit the agency's web site at www.atsdr.cdc.gov.

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Summary

Introduction

The Washington State Department of Ecology (Ecology) requested a health consultation from the Washington State Department of Health (DOH) to assess human health risk from exposure to the Van Stone Mine site in Stevens County, Washington. Environmental data from Ecology's 2013 remedial investigation (RI) were evaluated by DOH for potential health impacts.

Van Stone Mine is a former lead-zinc mine that operated intermittently between 1938 and 1993. A community of about 76 residents and a school district with about 40 students is located near the site. There have been a variety of community health concerns and comments noted in the past several years. These concerns included potentially drinking contaminated well water, presence of naturally-occurring asbestos, dust on roads near the school district, and the need for warning signs to be posted around the mine. Residents have said that recreational activities, including hiking and dirt-biking, have taken place at Van Stone Mine. People in this area use groundwater for their main source of tap water.

The purpose of this health consultation is to determine if exposure to contaminants from Van Stone Mine may cause adverse health effects for the surrounding community and visitors. DOH reached the following five conclusions regarding the Van Stone Mine site:

Conclusion 1

DOH concludes that physical hazards present on this site could harm people's health.

Basis for Decision

- The RI describes the potential for rock falls in pit walls, geologic instability around the Pit Lake, and structural instability of the tailings piles.
- It was observed from a site visit on May 29, 2014 that falls could occur if people were to climb around the abandoned mine infrastructure.
- There is evidence that areas of Van Stone Mine are being used for recreational purposes even though there are some gates and "No Trespassing" signs displayed.

Conclusion 2

DOH concludes that touching, breathing, or accidentally ingesting chemical contaminants in soil or sediment at Van Stone Mine is not expected to harm people's health.

Basis for Decision

- Non-cancer health effects are not expected with occasional exposures to the site.
- For carcinogenic contaminants, cancer risk was determined to range from “insignificant” (cadmium) to “very low” (arsenic).

Conclusion 3

DOH concludes that using private well water for drinking and bathing is not expected to harm people’s health.

Basis for Decision

- Non-cancer health effects are not expected with regular exposure to water.
- Arsenic in water was determined to be a “low” cancer risk.

Conclusion 4

DOH could not conclude whether swimming or wading in surface water at Van Stone Mine could harm people’s health.

Basis for Decision

- The RI analyzed filtered surface water samples, as opposed to unfiltered water samples. The resulting data could lead to an underestimate of the health risk posed by contaminants.

Conclusion 5

DOH could not conclude whether naturally-occurring asbestos is present at the site and could harm people’s health.

Basis for Decision

- Several reports reference the presence of tremolite rock at the mine site that can contain asbestos form fibers. However, the RI had limited numbers of samples that were only analyzed for the presence of chrysotile, which is a different type of rock that is also known to contain asbestos form fibers.

Next Steps

1) Signs should be installed around Van Stone Mine to warn people about physical hazards and potential health effects from exposure to contaminants found on site within three months of the finalization of this document.

2) Additional characterization of site materials should be completed to determine the potential presence and extent of tremolite asbestos.

3) DOH will work with Ecology to help draft the language displayed on warning signs.

4) DOH will provide input on the sampling plan for asbestos as requested by Ecology.

5) DOH will provide copies of this health consultation to Ecology, the NE Tri County Health District, the Onion Creek School District, and the public library located in the general store near Van Stone Mine.

For More Information

If you have any questions about this health consultation contact Amy Leang at 360-236-3357 or 1-877-485-7316 at Washington State Department of Health. For more information about ATSDR, contact the Center for Disease Control and Prevention (CDC) Information Center at 1-800-CDC-INFO (1-800-232-4636) or visit the agency's web site at www.atsdr.cdc.gov.

Statement of Issues

At the request of Washington State Department of Ecology (Ecology), the Washington State Department of Health (DOH) has prepared this health consultation for the Van Stone Mine site. The purpose is to determine whether exposure to contaminants from the site poses a health threat to the surrounding community and visitors (e.g., recreationalists and trespassers) using data collected during Ecology's 2013 remedial investigation (RI). The site is a former lead and zinc open pit mine with a legacy of contaminants in surface water, groundwater, sediments, and soil. DOH has completed this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

Site Description

Van Stone Mine was first identified as a contaminated site by Ecology due to past lead and zinc mining operations. It is structurally part of the Kootenay arc, a belt of sedimentary rock in northeastern Washington. The mine is located in Section 33, Township 38 North, Range 40 East, approximately 24 miles northeast of the city of Colville in Stevens County (see Figure 1). It is on the headwaters of Onion Creek, which is a tributary to the Columbia River. At an elevation of about 3,500 feet above sea level, climate is rain-snow dominated during the winter months at the mine.(1)

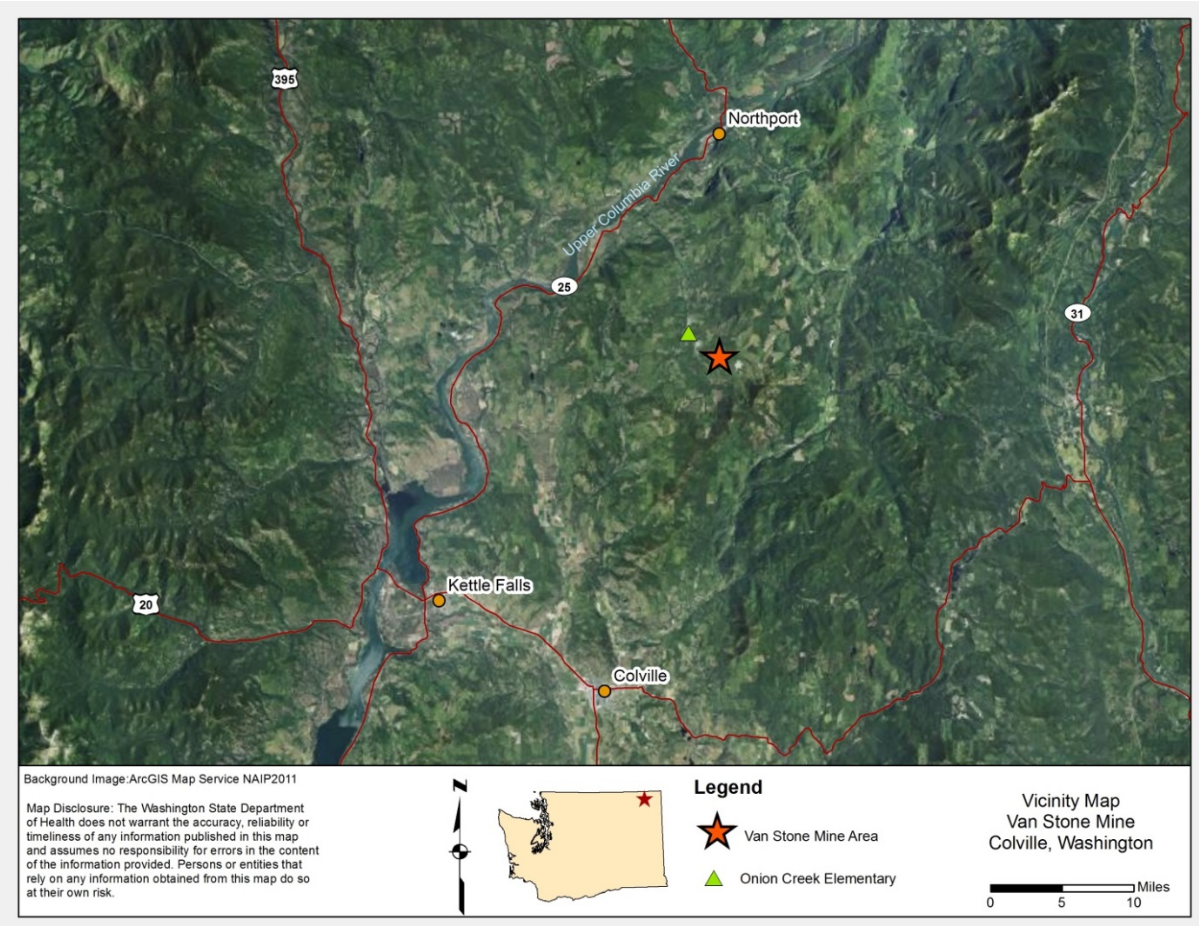

Figure 1: Vicinity Map of Van Stone Mine, Stevens County, WA

In order to evaluate environmental impacts from previous mining operations and ongoing contamination releases, the RI studied several areas of the mine. The total area of potentially disturbed land is estimated to be 328 acres and includes the mill area, tailings piles, tailings pipeline, access roads, and Onion Creek with tributaries. Samples from surface water, groundwater, soil, and sediment were collected and analyzed from these areas. The RI also included sampling and analysis of groundwater from seven residential wells, which were located near the Upper and Lower Tailings Piles (see Figure 2). The areas of the RI that were studied are described in more detail in the sections below.

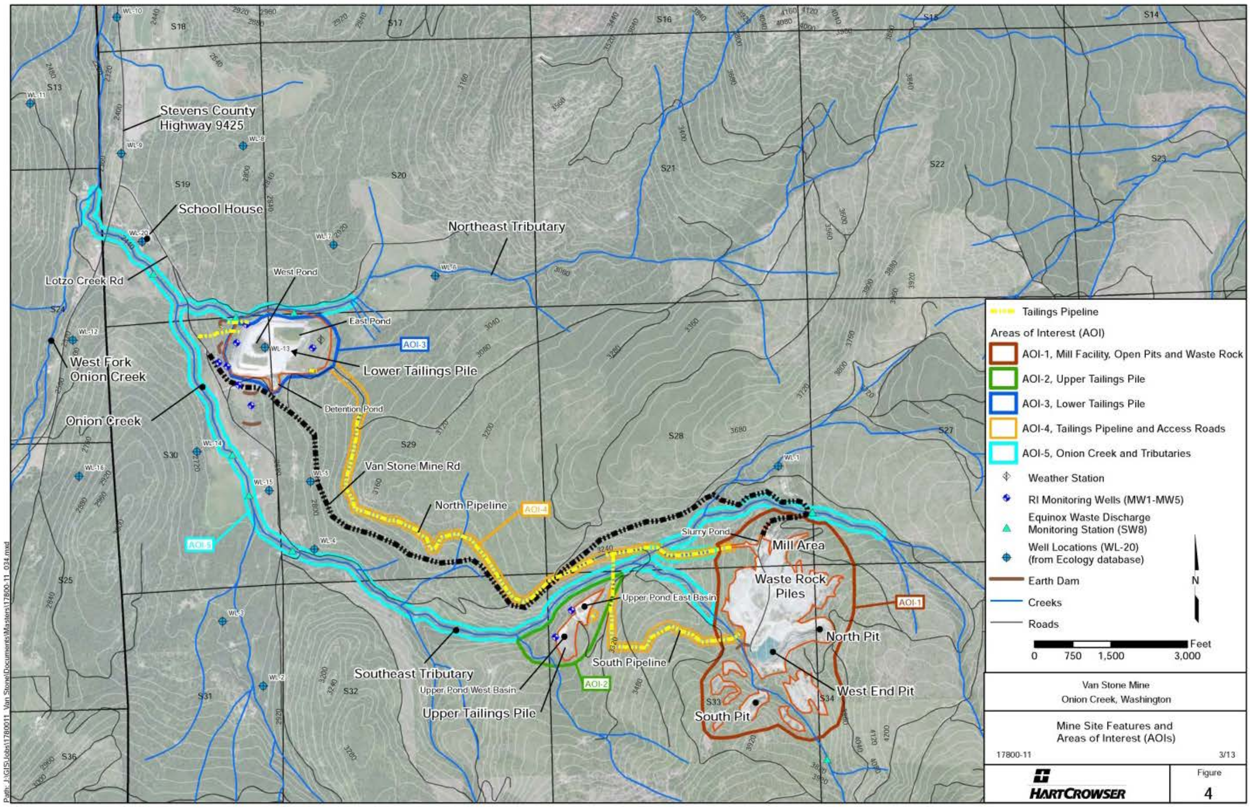

Figure 2: Site Map, Van Stone Mine, Stevens County, WA(1)

Mill Area

The mill area includes two open pits, stockpiles, waste rock piles, and concrete foundations. This was the area where ore rock was milled and processed, mining vehicles were maintained, and chemicals were stored. Therefore, in addition to the analyses of various metals in soil and surface water, this area also had stained soil samples collected for the presence of volatile organic chemicals, polychlorinated biphenyl ethers (PCBs), polycyclic aromatic hydrocarbons (PAHs), and fuel compounds.

Open Pits and Waste Rock Piles

Ore was excavated from the areas referred to as pits (See Figure 2). The larger of the open pits is the North Pit; it includes the West End Pit Lake that is about 4.5 acres and 100 feet deep. The other open pit, South Pit, is about 1,000 feet south of the West End Pit Lake. Surface water may be present seasonally in South Pit. The waste rock piles cover about 80 acres outside of the open pits, where rock was excavated. The waste rock sizes vary from large boulders to fine rock flour. Surface water from the open pits and soil from the waste rock piles were sampled for the presence of metals.

Tailings Piles

As a result of milling the ore and extracting metals from Van Stone Mine, tailings were produced as waste material. Tailings from the mill area were moved downhill through pipelines to the Upper Tailings Pile. The Upper Tailings Pile had a dam failure in 1961 and tailings flooded a tributary of Onion Creek. The Lower Tailings Pile (see Figures 2 and 3) was then constructed and used until 1993. The Upper Tailings Pile covers about 9.5 acres and has approximately 780,000 tons of tailings. In comparison, the Lower Tailings Pile covers approximately 40 acres and contains about 1.82 million tons of tailings. Surface soil and groundwater from both tailings piles and surface water from the Upper Tailings Pile were sampled for the presence of metals.

Tailings Pipeline

Tailings generated from the mill area were conveyed through pipes into the tailings piles. Two pipelines exist at this site – the North Tailings Pipeline and South Tailings Pipeline. Sections of the pipelines are damaged or deteriorating, so tailings are evident along much of the pipelines. There are many small releases along the pipes, but several large releases have been documented as well; the largest tailings release (along the North Tailings Pipeline) covered 33,000 square feet. Surface soil from along the tailings pipeline was sampled for the presence of metals.

Access Roads

Access roads were used by workers to travel between the mill area, tailings piles, and conveyance pipelines. Surface soil from Onion Creek Road, Lotze Creek Road, and Van Stone Mine Road was sampled for presence of metals.

Onion Creek and Tributaries

The tributaries drain the open pits, mill area, and upper watershed. Scattered piping was found near the Southeast Tributary, along with fine-grained material that resembles tailings on the creek bed. Along the Northeast Tributary, similar fine-grained material to tailings was found. Surface soil, sediment, and surface water from Onion Creek and tributaries were sampled for the presence of metals.

Land Use and Demographics

The land surrounding Van Stone Mine is designated for a variety of uses, including undeveloped forest, mining, agriculture, small-scale ranching, and rural residential. The predominant land use in the mining operations area is forestry. Recreational activities include hunting deer, dirt biking, and horseback riding. Developed areas include the several residential parcels on private lands near Onion Creek and its tributaries. Based on census data, there are about 76 residents within one mile of the Van Stone Mine site; this includes 6 young children, 9 elderly people, and 8 women of child-bearing age (See Figure 3). The Lower Tailings Pile is 0.4 miles west of the Onion Creek School House, where about 40 students attend school each year.(2) No tribal cultural resources were identified in this area.(1)

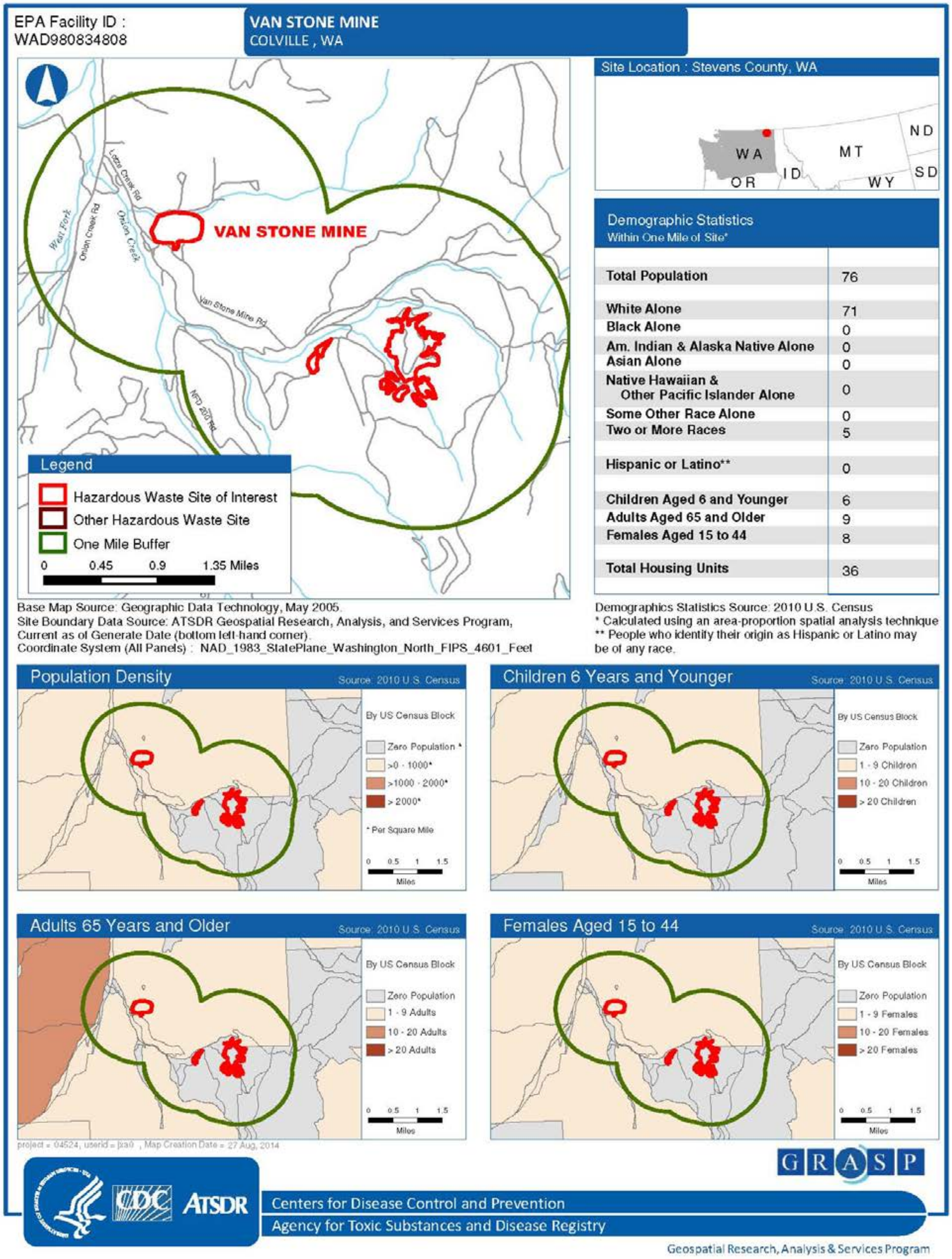

Figure 3: Demographics for Van Stone Mine Area, Stevens County, WA (Courtesy of Centers for Disease Control and Prevention / Agency for Toxic Substances and Disease Registry)

Community Health Concerns

There have been a variety of community health concerns and comments noted in the past several years. These concerns include potentially drinking contaminated well water, presence of naturally-occurring asbestos, dust on roads near the school district, and the need for warning signs to be posted around the mine. Residents have reported recreational activity on site, and noted that they have gone hiking and horse-back riding on site in the past. There has also been occasional dirt biking occurring on the Lower and Upper Tailings Piles. The Lower Tailings Pile, pond and dirt bike tracks can be seen in Figure 4, below. Some community members expressed health concerns with exposure to the site and were interested in learning more about potential health impacts in general.

(a) (b)

Figure 4: Lower Tailings Pile (a) view from Van Stone Mine Road and (b) view from top of pile, Van Stone Mine, Stevens County, WA (May 29, 2014)

Discussion

Remedial Investigation Data

The remedial investigation (RI) was completed in November 2013 and includes the most recent environmental data that DOH used for this health consultation. For a summary of samples from the RI that were evaluated in this health consultation, see Table 1, below. Five areas of interest within the site were studied during the RI: 1) mill area, open pits, and waste rock area; 2) upper tailings pile; 3) lower tailings pile; 4) pipeline and access roads; and 5) Onion Creek and tributaries. Samples from surface water, groundwater, soil, and sediment were evaluated during this investigation from the site. The RI also included sampling and analysis of groundwater from seven residential wells, which were located adjacent to the Upper and Lower Tailings Piles.(1)

Table 1: Summary Description of Environmental Sampling and Analysis from 2013 Remedial Investigation, Van Stone Mine, Stevens County, WA

Media	Sampling Location	n	Analysis of Sample
Groundwater	Residential Wells* Adjacent to Upper and Lower Tailings Piles	8	Total Metals
	Monitoring Wells - Upper and Lower Tailings Piles	7	Total Metals
Surface Water	Mill Area - South Pit Lake, West Lake	3	Dissolved Metals and Total Mercury
	Upper Tailings Pile - Seep Sample, Tributary Discharge Area	3	Dissolved Metals and Total Mercury
	Onion Creek	21	Dissolved Metals and Total Mercury
Stained Soil	Mill Area	10	Non-metals: Diesel/Motor Oil, Polychlorinated Biphenyls, Volatile Organic Chemicals
Surface Soil	Mill Area	52	Metals, Asbestos (limited data)
	Upper Tailings Pile	35	Metals
	Lower Tailings Pile	47	Metals
	Tailings Pipeline and Access Road	33	Metals
	Onion Creek	1	Metals
Sediment	Onion Creek and NE Tributary	22	Metals

n: number of samples
*Seven (7) residential wells were sampled – one field duplicate is represented in the number of samples.
Metals analyzed include Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Silver, Thallium, and Zinc.

Exposure Pathways Evaluation

To begin assessing possible health risks, exposure pathways need to be identified. An exposure pathway has five parts:

- Source of contamination (such as a mine);
- Environmental Media and Transport Mechanism (media that contaminants travel through, such as groundwater);
- Point of Exposure (like a private well);
- Route of Exposure (eating, drinking, breathing, or touching); and
- Receptor Population (people exposed).

An exposure pathway is complete when all five parts are present.(3) Based on environmental data available in the RI and input from the community, completed exposure pathways were identified for the following media: soil, sediment, surface water, and drinking water. Residents, trespassers, and visitors may have come in contact with contaminated media. Completed exposure pathways are present when the source of contamination has reached the population exposed. For these media, there is sufficient evidence that people have been exposed to the media in the past and are being currently exposed as well. The different media that people are exposed to will be further assessed through health risk assessment. These completed exposure pathways are summarized in Table 2, below.

Table 2: Exposure Pathways Evaluated in Human Health Risk Assessment, Van Stone Mine, Stevens County, WA

Source	Media	Exposure Point/Area	Exposure Route	Population Exposed	Completed Exposure Pathways
Van Stone Mine Waste and/or Naturally Occurring Contaminants	Soil	Mill Area, Tailings Piles, Tailing Pipelines, Access Roads, Onion Creek and Tributaries	Ingestion, Inhalation*, Dermal	Residents, Trespassers, Visitors	Past, Current
	Sediment	Onion Creek and Tributaries	Ingestion, Inhalation*, Dermal	Residents, Trespassers, Visitors	Past, Current
	Surface Water	Lower Tailings Pile	Ingestion, Dermal	Residents, Trespassers, Visitors	Past, Current
		Onion Creek and Tributaries	Ingestion, Dermal	Residents, Trespassers, Visitors	Past, Current
	Groundwater	Residential Wells	Ingestion, Dermal	Residents, Visitors	Past, Current

*Includes dust from soil or sediment that gets suspended in the air. Results from Ecology's weather station indicated that wind erosion is not a significant means of transporting dust from the Upper Tailing Piles to the surrounding community.(1)

Health Screening Evaluation

DOH screened the highest levels detected of each contaminant with ATSDR health comparison values in order to identify contaminants that may be a health concern. The health comparison values are set at concentrations much lower than what might cause harmful effects in people. This is done to be protective of more sensitive individuals (e.g., children and older adults).

Comparison values used for screening were ATSDR's cancer risk evaluation guides (CREGs), environmental media evaluation guides (EMEGs), and reference dose media evaluation guides (RMEGs).(3) If no ATSDR values exist for a certain chemical and/or media, DOH used U.S. Environmental Protection Agency (EPA) Regional Screening Levels for Residential Soil and the Washington Model Toxics Control Act (MTCA) Method A Soil Cleanup Levels for Unrestricted Land Uses.(4;5) If a contaminant is present but does not exceed the health comparison value, no further evaluation of that contaminant is necessary; DOH does not expect that it will pose a health threat. Also, no further evaluation is necessary if a contaminant was undetected in samples and not expected to be present in the area. When a contaminant is found to be above a health comparison value, or no health comparison value is available (e.g., lead [Pb]), further evaluation of that contaminant is required. These chemicals are called "contaminants of concern." However, a contaminant found above the comparison value does not necessarily mean that people are likely to become sick if they are exposed.

Tables B1 and B2 (in Appendix B – Contaminants of Concern from Initial Screening) summarize the results of health comparison value screening for identifying contaminants of concern.

Exposure Assessment

There are many factors that determine whether an exposure will cause adverse health effects. Factors include the concentration of chemicals a person is exposed to, duration of exposure, how chemicals enter the person (through touching, eating, and/or breathing), other chemicals a person is exposed to, an individual's age, health and nutritional status.(3) An exposure assessment uses environmental data to estimate doses of chemicals people are exposed to and predicts the risk of non-cancer and cancer health effects, when applicable, for each chemical. Exposure assumptions, dose estimations, and risk calculations can be viewed in Appendix C – Exposure Assessment Calculations.

Non-cancer Health Effects

After the dose is calculated, it is compared to ATSDR Minimal Risk Levels (MRLs) or the EPA Reference Dose (RfD) when the MRL is not available. MRLs and RfDs are levels at which no adverse health effects are expected. Hazard quotients (HQs) are calculated to assess potential non-cancer health effects.

$$\mathrm{HQ} = \frac{Estimated\ Dose}{MRL\ or\ RfD}$$

When HQs are equal to or below 1, no adverse health effects are expected. When HQs exceed 1 for a contaminant, the estimated exposure dose is compared to a no-observed-adverse-effect level (NOAEL) and/or a lowest-observed-adverse-effect level (LOAEL) to determine if there might be a health threat. Hazard quotient calculations and NOAEL[a]/LOAEL[b] comparisons can be viewed in Appendix D – Non-Cancer Exposure Assessment.

A different approach was used to assess the potential non-cancer health effects associated with exposure to lead because there are no MRLs of RfDs.[c] Instead, DOH used EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model. The model provides an estimate of blood lead levels in children from 0-7 years old who are exposed to lead.

Cancer Health Effects

Cancer is a common illness that increases in susceptibility with age. About 1 in 3 people living in the U.S. will develop cancer at some point in their lives.(6) For chemicals that are known to cause cancer, DOH estimates the cancer risk using calculated doses and chemical-specific cancer slope factors (CSF). Calculations and exposure parameters can be viewed in Appendix E – Cancer Risk Calculations.

ATSDR has qualitative terms to describe calculated cancer risk, such as low, slight, and moderate. For example, a "very low" estimate might describe an exposed population of a hundred thousand having a single additional case of cancer over background due to lifetime exposure to the contaminant.(3)

Arsenic and cadmium were the two contaminants of concern at this site requiring a cancer risk estimate.

Cancer Risk

Cancer risk estimates do not reach zero no matter how low the level of exposure to a carcinogen. Terms used to describe this risk are defined below as the number of cancer cases for the number of persons similarly exposed over a lifetime:

Term		# of Excess Cancers
Moderate	is approximately equal to	1 in 1,000
Low	is approximately equal to	1 in 10,000
Very low	is approximately equal to	1 in 100,000
Slight	is approximately equal to	1 in 1,000,000
Insignificant	is less than	1 in 1,000,000

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[a] NOAEL: The highest exposure level at which there are no biologically significant increases in the frequency or severity of adverse effect between the exposed population and its appropriate control; some effects may be produced at this level, but they are not considered adverse or precursors of adverse effects (U.S. Environmental Protection Agency).
[b] LOAEL: The lowest exposure level at which there are biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control group (U.S. Environmental Protection Agency).
[c] In 1988, the EPA decided against developing an RfD for lead due to the relatively high certainty of predicting its health effects with low levels in blood.

Health Effects Evaluation

The screening evaluation for this consultation identified several metal contaminants of concern in groundwater, surface water, soil, and sediment. These included antimony, arsenic, cadmium, copper, lead, mercury, and zinc. Contaminants of concern require further evaluation. Table 3 summarizes what contaminants of concern were found and where they were found.

No volatile organic compounds were found to be contaminants of concern in any of the areas sampled. For groundwater, only the results from the private wells were evaluated during this health consultation. The results from the monitoring wells were not assessed because the groundwater characterization is currently incomplete (1) and no one is drinking that groundwater. Based on our preliminary assessment of that data, however, groundwater from monitoring wells could pose a health threat if someone were to drink it.

Table 3: Contaminants of Concern Identified from Screening with Health Comparison Values, Van Stone Mine, Stevens County, WA

<table>
<tr><th>Media</th><th>Sampling Location</th><th>Contaminant(s) of Concern</th></tr>
<tr><td rowspan="2">Groundwater</td><td>Residential Wells Adjacent to Upper and Lower Tailings Piles</td><td>Arsenic</td></tr>
<tr><td>Monitoring Wells - Upper and Lower Tailings Pile</td><td>Arsenic, Cadmium, Chromium, Lead, Nickel</td></tr>
<tr><td>Surface Water*</td><td>Pit Lakes and Creek</td><td>Antimony, Cadmium</td></tr>
<tr><td rowspan="5">Surface Soil</td><td>Mill Area</td><td>Arsenic, Cadmium, Copper, Lead, Mercury, Zinc</td></tr>
<tr><td>Upper Tailings Pile</td><td>Arsenic, Cadmium, Lead</td></tr>
<tr><td>Lower Tailings Pile</td><td>Cadmium, Lead</td></tr>
<tr><td>Tailings Pipeline and Access Road</td><td>Arsenic, Cadmium, Lead</td></tr>
<tr><td>Onion Creek</td><td>Lead</td></tr>
<tr><td>Sediment</td><td>Onion Creek and NE Tributary</td><td>Lead</td></tr>
</table>

Note: No comparison value exists for lead in soil or sediment, so it is typically further evaluated as a contaminant of concern using a different method of exposure assessment.
*Analytical results are dissolved metal concentrations

Surface water samples were only analyzed for dissolved metals, with the exception of total mercury. Using dissolved metals results could result in an underestimation of the health risk posed by these chemicals.

The exposure assumptions used to evaluate the non-cancer and cancer health effects are provided in Appendix C. Appendix F contains the exposure assumptions for lead. The non-cancer health evaluations for each of the contaminants of concern are found in Appendix D – Non-Cancer Exposure Assessment. The cancer risk calculations for arsenic and cadmium can be found in Appendix E – Cancer Risk Calculations.

Information about each chemical of concern and our findings are summarized below. A brief summary of our health findings are also provided in Table 4 at the end of this section.

Antimony

Antimony is a naturally-occurring metal found in small amounts in the earth's crust. It can spread through the environment during mining operations, such as ore processing. Antimony does not degrade. It can get suspended in air for long periods of time, although most antimony will settle in soil and sediment. People can be exposed to antimony through inhalation, dermal absorption, and ingestion. The range of potential health effects resulting from exposure to antimony is largely uncharacterized. Antimony may irritate eyes, skin, and lungs when exposed through the air, as well as cause lung and heart problems. Stomach pain, diarrhea, vomiting, and stomach ulcers have also been reported. It is unknown whether exposure to antimony can cause cancer or birth defects.(7)

Antimony was only a chemical of concern in surface water. The highest concentration (0.013 parts per million [ppm]) of antimony found in surface water was used in estimating the dose a person would be exposed to during recreational activities (2 hours per day for 30 days each year to represent summer month type exposures). Calculated HQs were well below 1. However, surface water data were from filtered samples, which could lead to an underestimate in human health risk.

Arsenic

Arsenic is a naturally-occurring element in the Earth's crust. It is often referred to as a metal, although technically, it is a metalloid since it has properties of both metals and nonmetals. Arsenic is used in a variety of industrial applications. The most common application for arsenic is in wood preservation. Arsenic compounds are colorless, tasteless, and odorless, so it is difficult to tell whether arsenic is present in food, water, or air. Arsenic does not degrade, and can travel through the environment into different media including soil, sediment, surface water, groundwater, air, and also shellfish. Arsenic comes in two forms: organic and inorganic. Organic arsenic, often present in shellfish, is much less harmful to human health than inorganic arsenic. Inorganic arsenic is generally found in soil or sediment.(8)

All people are exposed to some levels of arsenic by eating food, drinking water, and breathing air. The most distinctive effect from exposure to elevated levels of arsenic is seen in the skin. Patches of darkened skin, corns, and other abnormal skin growth may appear on the palms, soles, and torso. Arsenic is a known carcinogen and may cause skin cancer to develop, as well as liver, bladder, and lung cancer. Other common health effects include fatigue, abnormal heart rhythm, and nerve function impairment that cause "pins and needles" sensations in the hands and feet. It is unknown whether arsenic causes birth defects.(8)

Inorganic arsenic occurs in many types of rock, and is especially common in ores that contain lead. Levels of arsenic can vary depending on soils present in a region. The average arsenic level in soils in the U.S. is around 3-4 ppm and 1 ppb in groundwater. However, there is a wide range of levels found depending on location of geologic deposits and proximity to mining sites.(8) The highest level of arsenic detected from this site was 45 ppm in soil and 5.3 ppb in groundwater.(1)

The EPA has established a maximum contaminant level (MCL) for arsenic in drinking water as 10 parts per billion (ppb).(9) MCLs are permissible levels set for public water systems. There are no state-wide standards for arsenic in private wells. However, DOH provides recommendations if levels in private wells exceed 10 ppb. Although the highest levels of arsenic sampled from residential groundwater do not exceed the MCL, the risk of developing health effects is not eliminated even when levels are below 10 ppb.

DOH evaluated the highest detected level of arsenic in surface soil (45 ppm) and private well water (0.0053 ppm). No adverse non-cancer health effects are expected from exposure to arsenic in either media. Lifetime excess cancer risk from exposure to drinking water and soil ranged from very low to low. The lifetime cancer risk from exposure to arsenic in soil (1.7E-05) is approximately equal to 2 in 100,000 excess cancers in a lifetime. This is considered a "very low" risk according to ATSDR. Lifetime cancer risk from exposure to arsenic in drinking water is approximately equal to 3 in 10,000 excess cancers in a lifetime. This is considered a "low" risk.

Cadmium

Cadmium is a naturally-occurring metal in the earth's crust, and is associated with zinc, lead, and copper ores. It can spread through the environment through mining processes and enter air, soil, and water. Inhalation health effects are well-characterized for cadmium. Workers chronically exposed to high levels of cadmium may die from lung damage. Breathing in lower levels of cadmium for long time periods may result in cadmium build-up in the kidneys, which may cause kidney disease. Cadmium is a probable human carcinogen through inhalation; it can cause lung cancer. People who smoke tobacco products have over four times the levels of cadmium in their blood as the national average level due to the fact that cadmium accumulates in tobacco leaves. Oral exposure may cause stomach irritation, leading to vomiting and diarrhea, and sometimes death if levels are very high. Ingesting lower levels of cadmium over a long period of time can cause bones to become fragile. Health effects from dermal exposure have not been well-characterized.(10)

The highest concentration of cadmium (180 ppm) was found in surface soil at the mill area. HQs were equal to or less than 1, so no adverse non-cancer health effects from cadmium are expected from exposure to soil. There is also an "insignificant" cancer risk (1.9E-8) associated with the inhalation of cadmium from soil particles.

The highest concentration of cadmium in surface water (0.0014 ppm) was found in the mill area (South Pit Lake). Resulting HQs from the exposure assessment using this concentration level were well below 1. However, surface water data were from filtered samples, which could lead to an underestimate in human health risk.

Copper

Copper is a metal that naturally occurs in the earth's crust. It is an essential element, and intake at low levels is required for humans and animals. High levels of copper can enter the environment from mining processes, industrial settings, and landfills. Copper does not break down, and it is found in many foods and beverages that we consume daily. People need to consume low levels of copper, but at high levels, copper can cause irritation to the nose, mouth and eyes, as well as headaches, dizziness, nausea, and diarrhea. As with many other chemicals, very high levels of copper intake can cause liver and kidney damage, and then death. The most recognized source of copper exposure is through drinking water from copper pipes. It is unknown whether copper is a carcinogen.(11)

Copper is only a contaminant of concern for surface soils at the mill area. The highest level of copper found in that area was 640 ppm. HQs were significantly below 1. As a result, no adverse non-cancer health effects are expected with copper.

Lead

Lead has been a contaminant of public health concern for decades. Blood lead levels are an indicator of lead exposure and have been decreasing over the decades due to regulations against lead-soldered cans and other lead-containing products. The single largest source of lead emission in the U.S. was from leaded gasoline. Since the EPA phased out lead in gasoline, levels of lead in the air has been significantly reduced. However, the Centers for Disease Control and Prevention (CDC) estimates that over 4 million households with children are still being exposed to high levels of lead (particularly from deteriorating lead-based paint). The CDC recommends that 5 micrograms per deciliter (µg/dL) be the blood lead level (BLL) at which public health actions be initiated.(12)

Lead exposure often does not have any particular symptoms, and no safe level of lead in blood has been identified. Unlike other contaminants, lead is stored in bones and remains in the body long after it is ingested. Exposure to lead can affect all parts of the body and cause developmental and nervous system toxicity, contributing to lower IQ scores. High levels of exposure can cause anemia, brain and kidney damage, and sometimes death. High levels of lead exposure also cause reproductive health effects, including miscarriages. Primary routes of exposure are inhalation of lead-containing particles and ingestion of lead.(13)

Lead in soil and sediment was further evaluated at this site. DOH typically evaluates possible health effects by selecting the maximum detected concentrations of each contaminant. However, given the number of soil and sediment samples taken from areas within Van Stone Mine and uneven distribution of the levels of lead within each area, DOH decided to also calculate the geometric mean of soil and sediment samples. The geometric mean is a weighted average calculated by multiplying all contaminant levels samples and taking the root of the number of observations. This kind of average takes into account unevenly distributed sampling data (such as many low values and a few high values) better than an arithmetic mean, where data points need to be normally distributed (few low values, many mid-range values, and a few high values).(3)

For children who are regularly exposed to lead contaminated soil, the IEUBK model can estimate the percentage of young children who are likely to have BLLs that exceed a level that may be associated with health problems (usually 10µg/dL). The EPA has set a target cleanup goal of having no more than 5% of the community (0-7 years old) with BLLs above 10 µg/dL. However, CDC has updated its definition for elevated BLL to greater than, or equal to, 5µg/dL. Based on this scenario, the IEUBK model predicts that about 4.8% will have blood lead levels greater than 5 µg/dL and a geometric mean BLL of 2.3 µg/dL for children. Using the maximum lead concentration found on site (26,000 ppm) in calculating lead exposure, this result from IEUBK is below the EPA target level of 5% and CDC's updated definition for elevated BLL of 5µg/dL. See Appendix F – Lead Exposure Assessment for the results of lead exposure assessment and calculations.

Mercury

Mercury can be found in the environment as a result of rocks and soil breaking down. It can be released into the environment both naturally and through human activities, including mining and fossil fuel combustion; levels of mercury released from human activities are much higher (over 200,000 times) than from natural occurrences. The primary routes of exposure to mercury include inhalation and ingestion. Exposures differ also between various forms of mercury. For example, methylmercury (found in fish) is much more readily absorbed through ingestion compared to inorganic mercury. Health effects of mercury include kidney damage and damage to the brain. Symptoms may include personality changes (irritability, nervousness), tremors, vision changes, deafness, hand-eye coordination problems, and problems with memory. The EPA has determined that mercury is a possible human carcinogen due to insufficient evidence.(14)

Mercury is only a contaminant of concern for surface soils found at the mill area. HQs from the exposure assessment using the highest level of mercury found in surface soil (2.8 ppm) were significantly below 1. As a result, mercury in soil is not expected to result in non-cancer health effects at the site.

Zinc

Zinc is a common element in the Earth's crust and is found in all foods. It is an essential element for humans; small amounts of it are needed for bodily functions. It spreads in the environment due to natural processes and through human activities, such as mining. The primary exposure routes to zinc include ingestion and inhalation. Exposure to high levels of zinc can produce adverse health effects including nausea, stomach cramps, and vomiting. Consistent exposure to high levels for several months may damage the pancreas and kidney, decrease levels of high-density lipoprotein (HDL) cholesterol, and cause anemia. The EPA has determined that zinc is not classifiable as a carcinogen to humans.(15)

Zinc is only a contaminant of concern for surface soils found at the mill area. HQs from the exposure assessment, using the highest level of zinc detected in soil (37,000 ppm), were significantly below 1. Zinc in soil is not a health concern at Van Stone Mine.

Health Effects Conclusions

The following table summarizes conclusions for human health effects expected from exposure to the media that were evaluated on site:

Table 4: Summary Conclusions on Health Effects from Exposure to Contaminants of Concern, Van Stone Mine, Stevens County, WA

Media	Sampling Location	Expected Non-cancer Health Effects	Cancer Risk Evaluation
Groundwater	Residential Wells – Adjacent to Upper and Lower Tailings Piles	**None**	Arsenic: *Low Risk*
Surface Water	Pit Lakes and Creek	**No conclusion***	N/A
Surface Soil	Mill Area, Upper and Lower Tailings Piles, Tailings Pipeline, Access Road, Onion Creek	**None**	Arsenic: *Very Low Risk* Cadmium: *Insignificant Risk*
Sediment	Onion Creek and NE Tributary	**None**	N/A

*Data were from filtered samples only – no conclusion could be made on exposures to unfiltered surface water.
See Appendix D for details on non-cancer health effects evaluation.
See Appendix E for details on cancer risk assessment.

DOH concurs with the RI report that physical hazards exist on site. The RI describes the potential for rock falls in pit walls, geologic instability around the Pit Lake and structural instability of the tailings piles. It was also observed on a site visit (May 29, 2014) that recreationalists could fall from climbing what remained of the mill facility infrastructure.

Data Gaps

Tremolite Documented at Van Stone Mine

There are both fibrous (asbestiform) and non-fibrous forms of tremolite. The non-fibrous form is the predominant form of tremolite, although there are many reports of tremolite asbestos across the U.S. spanning from Maryland to California.(16) Tremolite asbestos is known to be a human health hazard to people who have been involved in mining, milling, and handling ores and to residents who live close to mines who may be breathing in higher levels of airborne asbestos than in typical ambient air. Any type of asbestos exposure increases the likelihood of lung cancer, mesothelioma, and other non-cancer lung problems. Lung diseases may take many years to develop and diagnose. Preventing further exposure to asbestos and ceasing tobacco smoking are the most important steps in preventing and minimizing asbestos-related health problems.(16) Limited asbestos sampling and analysis was performed during the RI; chrysotile asbestos was the only form of asbestos evaluated. This analysis does not address the tremolite form and is insufficient to evaluate potential health effects from potential tremolite asbestos that may exist at the site.

DOH has found several published references that indicate the presence of tremolite at Van Stone Mine. The first documentation of tremolite at Van Stone Mine was published by Washington State Department of Natural Resources (DNR) in a 1956 report, where tremolite was listed as a non-ore mineral.(17) In a 1970 report, DNR cited the chief geologist for Asarco who also characterized Van Stone Mine as containing tremolite.(18) In 1974, the EPA characterized Van Stone Mine as a known location for fibrous (asbestiform) minerals to occur.(19) Finally, a 2010 report by the U.S. Geological Survey (USGS) describes Van Stone Mine as having a geological setting similar to other sites that hosts the fibrous asbestos form of tremolite. This report emphasizes that the geologic setting has the “potential” to host asbestos and therefore, site-specific detailed microscopic analyses is required for verification purposes.(20)

Children’s Health Considerations

Children’s health requires special attention in communities when there is contamination found in the environment. Children may be more vulnerable to exposure to environmental contaminants than adults; exposures and subsequent adverse health effects are often exacerbated for younger children compared to older children or adults.(3) The following factors contribute to the increased vulnerability of children:

- Children are smaller and receive higher doses of chemical exposure per body weight.
- Children’s developing bodies or systems are more vulnerable to toxic exposures especially during critical growth stages in which permanent damage may occur.

Children’s health was considered in this health consultation, and exposure scenarios treated children as the most sensitive population being exposed.

Conclusions

- Physical hazards present on this site could harm people's health.
- Touching, breathing, or accidentally ingesting chemical contaminants in soil or sediment at Van Stone Mine is not expected to harm people's health.
- Using private well water for drinking and bathing is not expected to harm people's health.
- DOH could not conclude whether swimming or wading in surface water at Van Stone Mine could harm people's health.
- DOH could not conclude whether naturally-occurring asbestos is present at the site and could harm people's health.

Recommendations

1) Signs should be installed around Van Stone Mine to warn people about physical hazards and potential health effects from exposure to contaminants found on site within three months of the finalization of this document.

2) Additional characterization of site materials should be completed to determine the potential presence and extent of tremolite asbestos.

Public Health Action Plan

1) DOH will work with Ecology to help draft the language displayed on warning signs.

2) DOH will provide input on the sampling plan for asbestos as requested by Ecology.

3) DOH will provide copies of this health consultation to Ecology, the NE Tri County Health District, the Onion Creek School District, and the public library located in the general store near Van Stone Mine.

DOH will provide additional support as requested by Ecology in the form of technical assistance or follow-up health consultations throughout their remediation process for Van Stone Mine.

Report Preparation

This health consultation for the Van Stone Mine site was prepared by the Washington State Department of Health (DOH) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, and procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. This report was supported by funds from a cooperative agreement with the Agency for Toxics Substances and Disease Registry, U.S. Department of Health and Human Services. This document has not been reviewed and cleared by ATSDR.

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Appendices

Appendix A – Glossary

Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Cancer Risk Evaluation Guide (CREG)	The concentration of a chemical in air, soil, or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a *comparison value* used to select contaminants of potential health concern and is based on the *cancer slope factor* (CSF).
Cancer Slope Factor (CSF)	A number assigned to a cancer causing chemical that is used to estimate its ability to cause cancer in humans.
Carcinogen	Any substance that causes cancer.
Chronic	Occurring over a long time (more than 1 year).
Comparison Value (CV)	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
Dermal Contact	Contact with (touching) the skin [see **route of exposure**].

Dose (for chemicals that are not radioactive)	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Environmental Media Evaluation Guide (EMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a comparison value used to select contaminants of potential health concern and is based on ATSDR's minimal risk level (MRL).
Environmental Protection Agency (EPA)	United States Environmental Protection Agency.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [see **acute exposure**], of intermediate duration, or long-term [see **chronic exposure**].
Groundwater	Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with **surface water**].
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see **route of exposure**].
Ingestion Rate (IR)	The amount of an environmental medium that could be ingested typically on a daily basis. Units for IR are usually liter per day (1/day) for water and milligrams per day (mg/day) for soil.
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].

Inorganic	Compounds composed of mineral materials, including elemental salts and metals such as iron, aluminum, mercury, and zinc.
Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.
Maximum Contaminant Level (MCL)	A drinking water regulation established by the federal Safe Drinking Water Act. It is the maximum permissible concentration of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system. MCLs are enforceable standards.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Minimal Risk Level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].
Model Toxics Control Act (MTCA)	The hazardous waste cleanup law for Washington State.
Monitoring Wells	Special wells drilled at locations on or off a hazardous waste site so water can be sampled at selected depths and studied to determine the movement of groundwater and the amount, distribution, and type of contaminant.
No Apparent Public Health Hazard	A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No Observed Adverse Effect Level (NOAEL)	The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.
Oral Reference Dose (RfD)	An amount of chemical ingested into the body (i.e., dose) below which health effects are not expected. RfDs are published by EPA.
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides that are not easily dissolved in water.
Parts Per Billion (ppb)/Parts Per Million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition size swimming pool, the water will contain about 1 ppb of TCE.
Reference Dose Media Evaluation Guide (RMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a *comparison value* used to select contaminants of potential health concern and is based on EPA's oral reference dose (RfD).
Remedial Investigation (RI)	The EPA or Ecology's process of determining the type and extent of hazardous material contamination at a site.
Route of Exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [see **inhalation**], eating or drinking [see **ingestion**], or contact with the skin [see **dermal contact**].
Surface Water	Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].
Volatile Organic Compound (VOC)	Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Appendix B – Contaminants of Concern from Initial Screening

Table B1: Contaminants of Concern in Surface Soil and Sediments, Van Stone Mine, Stevens County, WA

Media	Location	Chemical	Maximum Concentration (mg/kg)	Soil Comparison Value (mg/kg)	Reference
Surface Soil	Mill Area	Arsenic	45	15	Chronic EMEG Child
		Cadmium	180 J	5	Chronic EMEG Child
		Copper	640 J	500	Intermediate EMEG
		Lead	26000 J	(Appendix F)	IEUBK
		Mercury	2.8 J	2	WA MTCA A
		Zinc	37000	15000	Chronic EMEG Child
	Upper Tailings Pile	Arsenic	16	15	Chronic EMEG Child
		Cadmium	15 J	5	Chronic EMEG Child
		Lead	1200	(Appendix F)	IEUBK
	Lower Tailings Pile	Cadmium	35	5	Chronic EMEG Child
		Lead	9500	(Appendix F)	IEUBK
	Access Road	Lead	64	(Appendix F)	IEUBK
	Tailings Pipeline	Arsenic	21	15	Chronic EMEG Child
		Cadmium	25	5	Chronic EMEG Child
		Lead	1000	(Appendix F)	IEUBK
	Onion Creek and Tributaries*	Lead	46	(Appendix F)	IEUBK
Sediment		Lead	110	(Appendix F)	IEUBK

*Onion Creek and Tributaries had both surface soil and sediment samples collected, so there are two lead levels listed.
Mg/kg: milligrams per kilogram soil
J: Estimated value
IEUBK: Integrated Exposure Uptake Biokintetic model
ATSDR: Agency for Toxic Substances and Disease Registry
CV: Comparison Value
EMEG: Environmental Media Evaluation Guide
WA MTCA A: Washington Model Toxics Control Act Method A
Appendix F: see Appendix F for the separate evaluation of lead with IEUBK

Table B2: Contaminants of Concern in Surface Water and Groundwater, Van Stone Mine, Stevens County, WA

Media	Location	Chemical	Maximum Concentration (ppm)	Drinking Water Comparison Value (ppm)	Reference
Surface Water	Pit Lakes and Creek	Antimony	0.013	0.004	RMEG Child
		Cadmium	0.0014 T	0.001	Chronic EMEG Child
		Lead	0.0094	0.015	MCL
Groundwater	Residential Wells	Arsenic	0.0053	0.000023	CREG
		Lead	0.0053	0.015	MCL
Groundwater	Monitoring Wells	Arsenic	0.015	0.000023	CREG
		Cadmium	0.0095	0.001	Chronic EMEG Child
		Chromium	0.47	0.1	MCL
		Lead	0.22	0.015	MCL
		Nickel	0.31	0.2	RMEG Child

ppm: parts per million
T: Value is between the method detection limit and the method reporting limit.
MCL: Maximum Contaminant Level, Environmental Protection Agency
EMEG: Environmental Media Evaluation Guide
CREG: Cancer Risk Evaluation Guide
RMEG: Reference Dose Media Evaluation Guide

Appendix C – Exposure Assessment Calculations

Table C1: Exposure Assumptions for Exposure to Contaminants in Soil and Sediment Samples from Van Stone Mine, Stevens County, WA

Parameter	Value	Units	Comments
Concentration (C)	Variable	mg/kg	Maximum Detected Value
Conversion Factor (CF)	0.000001	kg/mg	Converts Contaminant Concentration from mg to kg
Ingestion Rate (IR) Child Older Child Adult	 100 50 50	mg/day	EPA Exposure Factors Handbook; Stanek, Calabrese, et al.[d,e]
Exposure Frequency (EF)	30	days/year	Approximates Exposures Every Weekend in Summer Months (21)
Exposure Duration (ED)	30 (5,10,15)	years	Number of Years at One Residence (Child, Older Child, Adult Years)
Body Weight (BW) Child Older Child Adult	 15 41 72	kg	0 to 5 Year Old Child Average Body Weight Older Child Average Body Weight Adult Average Body Weight
Surface Area (SA) Child Older Child Adult	 2900 2900 5700	cm^2	EPA Exposure Factors Handbook
Averaging $Time_{non-cancer}$ (AT)	Variable	days	Equal to Exposure Duration
Averaging $Time_{cancer}$ (AT)	27375	days	75 years
Cancer Slope Factor (CSF)	Variable	$(mg/kg/day)^{-1}$	Use 5.7 for Arsenic, EPA
24 hour Absorption Factor (ABS)	Variable	unitless	Arsenic: 0.03, Other Metals: 0.01
Oral Route Adjustment Factor (ORAF)	1	unitless	Non-cancer/Cancer Default
Adherence Duration (AD)	1	days	EPA Exposure Factors Handbook
Adherence Factor (AF) Child, Older Child Adult	 0.2 0.07	mg/cm^2	 AF for Children Playing in Wet Soil AF for Residential Adult Gardeners
Inhalation Rate (IHR) Child Older Child Adult	 8.3 14 15.2	m^3/day	EPA Exposure Factors Handbook
Soil Matrix Factor (SMF)	1	unitless	Non-cancer/Cancer Default
Particulate Emission Factor (PEF)	6.00E+08	m^3/kg	Model Parameters 0% Grass Cover

mg: milligram; kg: kilogram; cm^2: square centimeters ; m^3: cubic meters
$(mg/kg\text{-}day)^{-1}$: inverse of milligrams per kilogram body weight per day
EPA: U.S. Environmental Protection Agency

[d] Stanek, E.J. and E.J. Calabrese. 2000. Daily soil ingestion estimates for children at a Superfund site. *Risk Anal.* 20(5):627–635.
[e] Stanek, E.J., E.J. Calabrese, and M. Zorn. 2001. Biasing factors for simple soil ingestion estimates in mass balance studies of soil ingestion. *Human Ecology. Risk Assess.* 7:329–355.

Table C2: Exposure Assumptions for Exposure to Contaminants in Water Samples from Van Stone Mine, Stevens County, WA

Parameter	Value	Units	Comments
Concentration (C)	Variable	mg/kg	Maximum Detected Value
Conversion Factor (CF)	0.000001	kg/mg	Converts Contaminant Concentration from mg to kg
Ingestion Rate (IR) – Incidental	0.05	liters/hour	EPA Exposure Factors Handbook
Ingestion Rate (IR) – Drinking Water Child Older Child Adult	 0.9 1.0 1.4	liters/day	EPA Exposure Factors Handbook
Exposure Frequency (EF) – Surface Water	30	days/year	Approximates Exposures Every Weekend in Summer Months(21)
Exposure Frequency (EF) – Drinking Water	350	days/year	Residential Exposure Time
Hours/Event (t) - Surface Water	2	hours /event	Hours Spent Exposed to Surface Water (Full Body Exposure)(21)
Hours/Event (t) – Drinking Water	0.5	hours/event	Approximates Shower Time and Other Daily Dermal Exposures to Water
Events/Day (t)	1	event/day	1 Exposure Event for Each Day of Exposure
Exposure Frequency (EF) - Drinking Water	350	days/year	
Exposure Duration (ED)	30 (5,10,15)	years	Number of Years at One Residence (Child, Older Child, Adult Years)
Body Weight (BW) Child Older Child Adult	 15 41 72	kg	0 to 5 Year Old Child Average Body Weight Older Child Average Body Weight Adult Average Body Weight
Surface Area (SA) Child Older Child Adult	 6640 11800 20000	cm^2	EPA Exposure Factors Handbook
Averaging $\text{Time}_{\text{non-cancer}}$ (AT)	Variable	days	Equal to Exposure Duration
Averaging $\text{Time}_{\text{cancer}}$ (AT)	27375	days	75 years
Cancer Potency Factor (CPF)	Variable	$mg/kg/day^{-1}$	Use 5.7 for Arsenic, EPA
Oral Route Adjustment Factor (ORAF)	1	unitless	Non-cancer/Cancer Default
Adherence Duration (AD)	1	days	EPA Exposure Factors Handbook
Skin Permeability Coefficient (K_p) for Evaluated Inorganics	0.001	cm/hr	EPA Risk Assessment Guidance for Superfund Part E
Event Frequency (EF)	1	event/day	

mg: milligram
kg: kilogram
cm^2: square centimeters
$(mg/kg\text{-}day)^{-1}$: inverse of milligrams per kilogram body weight per day
EPA: U.S. Environmental Protection Agency

Exposure dose and cancer risk calculations:

Exposure assumptions given in Table C1 and C2 above were used with the following equations to estimate contaminant doses a person in each general age group would receive from seasonal recreational exposure to Van Stone Mine contaminants. Doses were then used to calculate hazard quotients (see Appendix D – Non-Cancer Exposure Assessment). For carcinogenic contaminants of concern, cancer risk was also calculated in addition to hazard quotients.

Total Dose from soil or sediment = Ingestion dose + dermal dose + inhalation dose
Total Dose from water[f] = Ingestion dose + dermal dose

Ingestion Route

$$\text{Dose}_{\text{non-cancer}} = \frac{C \times CF \times IR \times EF \times ED}{BW \times AT_{non-cancer}}$$

$$\text{Cancer Risk} = \frac{C \times CF \times IR \times EF \times CPF \times ED}{BW \times AT_{cancer}}$$

Dermal Route

$$\text{Dermal Transfer (DT)} = \frac{C \times AF \times ABS \times AD \times CF}{ORAF}$$

$$\text{Dose}_{\text{non-cancer}} = \frac{DT \times SA \times EF \times CPF \times ED}{BW \times AT_{non-cancer}}$$

$$\text{Cancer Risk} = \frac{DT \times SA \times EF \times CPF \times ED}{BW \times AT_{cancer}}$$

Inhalation Route

$$\text{Dose}_{\text{non-cancer}} = \frac{C \times IR \times EF \times ED \times SMF \times (\frac{1}{PEF})}{BW \times AT}$$

$$\text{Cancer Risk} = \frac{C \times IR \times EF \times ED \times SMF \times CSF \times (\frac{1}{PEF})}{BW \times AT_{cancer}}$$

[f] Metals are unlikely to be inhaled from water. Therefore, no inhaled dose was included in total dose from water since only metals were contaminants of concern in water.

Appendix D – Non-Cancer Exposure Assessment

Table D1: Surface Soil and Sediment Exposure Doses and Hazard Calculations, Van Stone Mine, Stevens County, WA

Contaminant	Concentration (mg/kg)	Age Group	Estimated Dose (mg/kg/day)			Total Dose (mg/kg/day)	MRL		Hazard Quotient (Total Dose/MRL)
			Incidental Ingestion	Dermal Contact	Inhalation of Particulates				
Arsenic	45	Child	2.5E-05	4.3E-06	3.4E-09	2.9E-05	0.0003		0.10
		Older Child	4.5E-06	1.6E-06	2.1E-09	6.1E-06			0.02
		Adult	2.6E-06	6.2E-07	1.3E-09	3.2E-06			0.01
Cadmium*	180	Child	9.9E-05	5.7E-06	1.4E-08	1.0E-04	0.0001	5.50E-08 (I)	1, 0.2
		Older Child	1.8E-05	2.1E-06	8.4E-09	2.0E-05		3.40E-08 (I)	0.2, 0.2
		Adult	1.0E-05	8.2E-07	5.2E-09	1.1E-05		2.10E-08 (I)	0.1, 0.2
Copper	640	Child	3.5E-04	2.0E-05	4.9E-08	3.7E-04	0.01[a]		0.04
		Older Child	6.4E-05	7.4E-06	3.0E-08	7.2E-05			0.01
		Adult	3.7E-05	2.9E-06	1.9E-08	3.9E-05			0.004
Mercury**	2.8	Child	1.5E-06	8.9E-08	2.1E-10	1.6E-06	0.0003[b]		0.01
		Older Child	2.8E-07	3.3E-08	1.3E-10	3.1E-07			0.001
		Adult	1.6E-07	1.3E-08	8.1E-11	1.7E-07			0.0006
Zinc	37000	Child	2.0E-02	1.2E-03	2.8E-06	2.1E-02	0.3		0.07
		Older Child	3.7E-03	4.3E-04	1.7E-06	4.1E-03			0.01
		Adult	2.1E-03	1.7E-04	1.1E-06	2.3E-03			0.01

Location of samples taken from Area of Interest -1/Mill area
mg: milligram; kg: kilogram
MRL: Agency for Toxic Substances and Disease Registry Chronic Oral Minimal Risk Levels
*Unlike the other contaminants, Cadmium causes health effects primarily through inhalation. Separate inhalation route hazard quotient is evaluated using chronic inhalation MRL.
I) Inhalation MRL; see formula section at the end of this Appendix for the derivation of these values. The estimated dose from inhalation was divided by this value to calculate the Hazard Quotient.
a) Chronic Oral MRL is unavailable, so Intermediate Oral MRL was used instead.
b) Oral MRLs for elemental mercury were not available, so methylmercury Oral Chronic MRL was used instead.

Formula to convert units from mg/m^3 to mg/kg/day[g]:

RfD_{inhal} = (RfC*IR*AR)/BW*100

Reference Concentrations used:
MRL of Cadmium chronic inhalation = 0.00001 mg/m^3
NOAEL used for Cadmium chronic inhalation = 0.0014 mg/m^3

RfD_{inhal} = Reference Dose inhaled (mg/kg/day)
RfC = Reference concentration in air (mg/m^3)
IR = Inhalation Rate (m^3/day)
AR = Absorption Rate (100% assumed)
BW = Body Weight (kg)

[g] Environmental Protection Agency. 2004. Superfund Chemical Data Matrix, Part 2 - Data Selection Methodology. p.7.

Table D3: Surface Water Exposure Doses and Hazard Calculations, Van Stone Mine, Stevens County WA

Contaminant	Concentration (ppm)	Age Group	Estimated Dose (mg/kg/day)		Total Dose (mg/kg/day)	MRL or RfD (mg/kg/day)	Hazard Quotient (Total Dose/MRL or RfD)
			Incidental Ingestion	Dermal Contact			
Antimony	0.013	Child	7.1E-06	9.5E-07	8.1E-06	RfD: 0.0004	0.02
		Older Child	2.6E-06	6.2E-07	3.2E-06		0.01
		Adult	1.5E-06	5.9E-07	2.1E-06		0.01
Cadmium	0.0014 T	Child	7.7E-07	1.0E-07	8.7E-07	MRL: 0.0001	0.01
		Older Child	2.8E-07	6.6E-08	3.5E-07		0.003
		Adult	1.6E-07	6.4E-08	2.2E-07		0.002

Location of samples: Mill area
T: Value is between the method detection limit and the method reporting limit.
ppm: parts per million
mg: milligram
kg: kilogram body weight
MRL: Chronic Oral Minimal Risk Level from Agency for Toxic Substances and Disease Registry
RfD: Reference Dose from Environmental Protection Agency

Table D4: Drinking Water/Groundwater Exposure Doses and Hazard Calculations, Van Stone Mine, Stevens County, WA

Contaminant	Concentration (ppm)	Age Group	Estimated Dose (mg/kg/day)		Total Dose (mg/kg/day)	MRL (mg/kg/day)	Hazard Quotient (Total Dose/MRL)
			Ingestion	Dermal Contact			
Arsenic	0.0053	Child	3.0E-04	1.1E-06	3.1E-04	0.0003	1
		Older Child	1.2E-04	3.7E-07	1.2E-04		0.4
		Adult	9.9E-05	2.4E-07	9.9E-05		0.3

Assumed shower time: 0.5 hours/day, 350 days/year ; Antimony and cadmium: Permeability coefficient = 0.001 cm/hr
ppm: parts per million
mg: milligram
kg: kilogram body weight
MRL: Minimal Risk Levels from Agency for Toxic Substances and Disease Registry

Appendix E – Cancer Risk Calculations

Table E1: Cancer Risk Calculations for Exposure to Arsenic in Soil, Van Stone Mine, Stevens County, WA

C (mg/kg)	EPA Cancer Class	Age Group	Estimated Dose (mg/kg/day)			Total Dose (mg/kg/day)	Cancer Potency Factor $(mg/kg/day)^{-1}$	Increased Cancer Risk			Total Cancer Risk
			Incidental Ingestion	Dermal Contact	Inhalation			Incidental Ingestion	Dermal Contact	Inhalation	
45	A	Child	1.6E-06	9.5E-08	2.3E-10	1.7E-06	5.7E+00	9.4E-06	5.4E-07	1.3E-09	9.9E-06
		Older Child	6.0E-07	7.0E-08	2.8E-10	6.7E-07		3.4E-06	4.0E-07	1.6E-09	3.8E-06
		Adult	5.1E-07	4.1E-08	2.6E-10	5.5E-07		2.9E-06	2.3E-07	1.5E-09	3.2E-06
								Lifetime Cancer Risk			**1.7E-05**

C: Concentration; ppm: parts per million
EPA: Environmental Protection Agency; Cancer Class A: Human Carcinogen
mg: milligram; kg: kilogram body weight

Table E2: Cancer Risk Calculations for Exposure to Arsenic in Drinking Water, Van Stone Mine, Stevens County, WA

C (ppm)	EPA Cancer Class	Age Group	Estimated Dose (mg/kg/day)		Total Dose (mg/kg/day)	Cancer Slope Factor $(mg/kg/day)^{-1}$	Increased Cancer Risk		Total Cancer Risk
			Ingestion	Dermal Contact			Ingestion	Dermal Contact	
0.0053	A	Child	2.0E-05	7.5E-08	2.0E-05	5.7E+00	1.2E-04	4.3E-07	1.2E-04
		Older Child	1.7E-05	9.8E-08	1.7E-05		9.4E-05	5.6E-07	9.5E-05
		Adult	2.0E-05	1.4E-07	2.0E-05		1.1E-04	8.0E-07	1.1E-04
							Lifetime Cancer Risk		**3.2E-04**

Assumed shower time: 0.5 hours/day, 350 days/year
C: Concentration; v
EPA: Environmental Protection Agency; Cancer Class A: Human Carcinogen
mg: milligram; kg: kilogram body weight

The lifetime cancer risk from exposure to arsenic in soil (1.7E-05) is approximately equal to 2-in-100,000 excess cancers in a lifetime. This is considered a “very low” risk according to ATSDR. Lifetime cancer risk from exposure to arsenic in drinking water (3.2E-04) is approximately equal to 3 in 10,000 excess cancers in a lifetime. This is considered a “low” risk according to ATSDR.

Table E3: Cancer Risk Calculations for Inhalation of Cadmium from Soil Particles, Van Stone Mine, Stevens County, WA

C (ppm)	EPA Cancer Class	Age Group	Estimated Dose (mg/kg/day)	Cancer Slope Factor $(mg/kg/day)^{-1}$	Total Cancer Risk
180	B1	Child	9.1E-10	6.3E+00	5.7E-09
		Older Child	1.1E-09		7.1E-09
		Adult	1.0E-09		6.6E-09
				Lifetime Cancer Risk	**1.9E-08**

*See formula section at the end of this Appendix for the derivation of this value.
C: Concentration; ppm: parts per million
EPA: Environmental Protection Agency; Cancer Class B1: Probable Human Carcinogen
mg: milligram; kg: kilogram body weight

Lifetime cancer risk for the inhalation of cadmium from soil particles (1.9E-08) is approximately equal to 2 in 100,000,000 excess cancers in a lifetime. This is considered an "insignificant" risk.

Formula to derive Cancer Slope Factor (CSF) from Air Unit Risk[h]:

$$\text{Air unit risk} = \text{risk per } \mu g/m^3 = \text{CSF} \times \frac{1}{70} kg \times 20\ m^3/day \times 0.001$$

$$\text{Air unit risk for Cadmium}^{i} = 0.0018 \text{ per } \mu g/m^3$$

$$\text{CSF} = \frac{Air\ unit\ risk}{\frac{1}{70}kg \times 20\frac{m^3}{day} \times 0.01} = \frac{0.0018\ per\ \mu g/m^3}{\frac{1}{70}kg \times 20\frac{m^3}{day} \times 0.001} = 6.3\ (mg/kg/day)^{-1}$$

[h] Environmental Protection Agency. 1989. Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual (Part A). p. 7-13.
[i] Environmental Protection Agency. 2012. Integrated Risk Information System, Cadmium (CASRN 7440-43-9). < http://www.epa.gov/iris/subst/0141.htm>.

Appendix F – Lead Exposure Assessment

Table F1: Lead Concentrations in Soil and Sediment at Van Stone Mine, Stevens County, WA

Media	Location	n	Maximum Concentration (ppm)	Geometric Mean Concentration (ppm)
Surface Soil	Mill	53	26000	172
	Upper Tailings Pile	36	1200	32
	Lower Tailings Pile	48	9500	40
	Tailings Pipeline	18	1000	113
	Access Road	15	64	11
	Onion Creek	1	46	N/A
Sediment	Onion Creek and Tributaries	22	110	21

n: number of samples analyzed
ppm: parts per million

Assumptions:

1. Children may be exposed to lead at site and home.
2. Concentration of lead at site (Maximum - 26000 ppm; Max Geo mean – 172 ppm).
3. A child visits the site 0.082 days per week (30 days per year = (30/7)/52 days per week) for 2 hours per day.
4. Residential soil concentration of 100 ppm.

Apportioning relative frequency (F) of exposure across locations according to hours awake:

$$F_{site} = \frac{2\text{hr/day} \times 0.082 \text{ day/week}}{12\text{hr/day} \times 7 \text{ days/week}} = \frac{0.17}{84} = 0.002$$

$F_{home} = (1.0 – 0.002) = 0.998$

Deriving a weighted soil lead concentration (PbS_w) from home and site:
$PbS_w = (PbS_{home} \times F_{home}) + (PbS_{site} \times F_{site})$

Maximum Concentration
PbS_w = (100 ppm x 0.998) + (26000 ppm x 0.002)
PbS_w = 99.8 ppm + 52 ppm = **152 ppm**

Maximum Geometric Mean
PbS_w = (100 ppm x 0.998) + (172 ppm x 0.002)
PbS_w = 99.8 ppm + 0.344 ppm = **100 ppm**

Table F2, below, shows how the IEUBK model predicts that about 4.8% of children ages 0-84 months exposed to the maximum lead concentration in soil from Van Stone Mine will have blood lead levels greater than 5 µg/dL. No public health action is necessary.

Table F2: Blood Lead Concentrations at Varying Age Ranges for Children Under Age 7, Exposed to Maximum Lead Concentration in Soil at Van Stone Mine, Stevens County, WA

IEUBK Output		
Age Range (months)	GM PbB (µg/dL)	Percent >5 µg/dL
0-84	**2.3**	**4.8**
0-12	2.4	5.9
12-24	2.9	12
24-36	2.7	9.2
36-48	2.5	7.3
48-60	2.1	3.3
60-72	1.8	1.5
72-84	1.6	0.83

Maximum lead concentration used in IEUBK model: 152 parts per million
µg/dL: micrograms per deciliter
GM PbB: Blood lead geometric mean, EPA's target cleanup goal is no more than 5% of the community (0-84 months) with blood lead levels above 5 µg/dL

For children who are regularly exposed to lead-contaminated soil, the IEUBK model can estimate the percentage of young children who are likely to have blood lead levels (BLLs) that exceed a level that may be associated with health problems (usually 10µg/dL). The EPA has set a target cleanup goal of having no more than 5% of the children (0-7 years old) with BLLs above 10 µg/dL. However, CDC has updated its definition for elevated BLL to greater than, or equal to, 5µg/dL. Using the maximum lead concentration found on site (26,000 ppm) in calculating lead exposure, this result from IEUBK is below the EPA target level of 5% and CDC's updated definition for elevated BLL of 5µg/dL.

Appendix G – Arsenic and Your Private Well

How are people exposed to arsenic?

Everyone has some daily exposure to arsenic because it is a naturally-occurring chemical element that is normally found in water, soil, indoor house dust, air, and food.

Arsenic in your water supply can get into your body when you drink the water or use it to cook or prepare food and beverages.

Arsenic is not absorbed very well through the skin and does not easily evaporate from water. As a result, bathing or washing dishes in arsenic-contaminated water, is unlikely to cause health problems.

Arsenic gets into well water through natural processes. As ground water flows through rocks and soil that contain arsenic, some of the arsenic dissolves into the water. Drinking water in Washington typically contains less than 3 parts of arsenic per billion parts of water (often abbreviated as 3 ppb). For comparison, 3 ppb is about equal to adding one teaspoon of arsenic to an acre of water that is 4 feet deep. However, levels from 10 ppb to 33,000 ppb have been found in some wells in Washington. These are usually associated with ground water located in rock or soil that has a naturally high content of arsenic.

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For more information, contact the Washington State Department of Health at 1-877-485-7316 or www.doh.wa.gov/etoxcontact.

This document is available in other formats for people with disabilities. To submit a request, please call 1-800-525-0127 (TDD/TTY call 711).

Arsenic
and Your Private Well

Arsenic is found in well water throughout Washington, sometimes at levels that may cause health problems.

Testing a water sample is the only way to know how much arsenic is present.

The Washington State Department of Health recommends that water used for drinking or food preparation contain no more than 10 parts per billion (ppb) arsenic.

Washington State Department of Health

What health problems can be caused by arsenic?

Swallowing relatively large amounts of arsenic (even just one time) can cause mild symptoms, serious illness, or in extreme cases, death. Milder effects may include swelling of the face, nausea, vomiting, stomach pain, or diarrhea. Serious effects may include coma, internal bleeding, or nerve damage causing weakness or loss of sensation in the hands, arms, feet, or legs. Only a few private drinking water wells in Washington have been found to have this much arsenic.

Long-term exposure to smaller amounts of arsenic is more common and can increase the risk of developing cancer of the bladder, lung, skin, liver, kidney, or prostate. Other health effects may include high blood pressure, narrowing of the blood vessels, nerve damage, anemia, diabetes, stomach upset, and skin changes.

Talk with your health care provider if you think you have any health problems that may be caused by exposure to arsenic.

Should I be concerned?

Most health problems from long-term arsenic exposure are common illnesses that affect many people and have several possible causes besides arsenic.

Even with relatively high levels of arsenic in the water, we expect that these health problems usually are not caused by arsenic exposure, but are mostly due to other factors such as diet, genes, lifestyle, other chemicals, and preexisting illness.

Still, arsenic is known to increase the risk of developing these illnesses and likely contributes to some of the cases we see.

It is difficult to predict whether arsenic in drinking water will affect you, or what the effects will be. The risk that you will get sick depends on:

- Your individual sensitivity to arsenic.
- The amount of arsenic in the water.
- How much water you consume.
- How many years you drink the water.

Exposures that can cause serious health problems for some people may have no effect on others. Also, two people with similar exposures may develop totally different health problems. *However, more exposure to arsenic increases the likelihood that health problems will occur. Reducing exposure reduces the risk.*

Should I get my well tested for arsenic?

We encourage you to test your private well to evaluate the safety of your drinking water supply. Arsenic levels are higher than 10 ppb in many wells in Washington. The only way to know how much arsenic is in your water is to test it.

Because the amount of arsenic in well water can vary throughout the year, you should test for it in late summer and in the early spring to see if there are seasonal differences.

Laboratories usually charge $20 to $35 for the test. You can find a list of labs online at: https://fortress.wa.gov/ecy/laboratorysearch or by calling the Washington State Department of Ecology's Laboratory Accreditation Unit at 360-871-8840. The laboratory can provide instructions for taking a sample and will often supply a container.

What do my test results mean?

To lower people's risk of health problems, the federal Safe Drinking Water Act requires 10 ppb or less arsenic in *public drinking water suppliers* that serve more than fourteen homes. When setting this requirement for arsenic, the U.S. Environmental Protection Agency considered the health risks, as well as the cost and difficulty of removing arsenic down to that amount.

Although a few counties in Washington have rules for arsenic in private water systems, *there is no state-wide standard for arsenic in private wells.* Where there are no county rules, it is up to each private well owner to decide whether he or she wants to take steps to reduce the levels of arsenic in their well water.

We recommend that water used for drinking or food preparation contain no more than 10 ppb arsenic. While reducing arsenic below 10 ppb can lower your chance of developing health effects, it is not low enough to completely eliminate that risk.

If your water contains between 10 ppb and 50 ppb arsenic, your chance of developing health problems increases. We recommend you not drink water containing these levels or use it for food preparation over the long term.

In either case, you will need to balance the health risks, costs, and convenience when deciding whether or not to continue to use your water supply.

If your water contains more than 50 ppb arsenic, we recommend you stop using it immediately for drinking and food preparation.

Since arsenic does not pass through your skin very easily and does not easily evaporate, it is okay to bathe and clean with water unless it contains more than 500 ppb. If the levels in your water are greater than 500 ppb, you should call your local health department or the Department of Health for advice.

How can I reduce my exposure to arsenic from my well?

There are several ways to reduce your exposure to arsenic in your well water. Each alternative has advantages and disadvantages to consider. If you have arsenic in your water above 500 ppb, you should talk to your local health department or the Department of Health before choosing an option.

Use Bottled Water

Drinking and cooking with bottled water can reduce your exposure immediately while you consider your options. However, it can be inconvenient and costly in the long run. You should also contact the bottled water supplier to ask about the levels of any impurities, including arsenic, that their water may contain.

Treat the Well Water

Many water filters on the market can improve the taste and remove odors from drinking water but do not remove arsenic. Some home water treatment systems that use reverse osmosis, distillation, or special filtration material can reduce the amount of arsenic in the water. These systems vary in cost and the amount of water they can supply every day. Point-of-entry equipment, commonly referred to as a whole-house system, treats all the water used in the house. Point-of-use systems treat water at a single tap, such as a kitchen sink faucet.

The quality of your water will affect how well the treatment system works and how much maintenance it will require.

We recommend installing equipment that has been certified by NSF International, a not-for-profit public health and safety company that tests home water treatment systems. Call 1-800-673-6275 or go to their website, http://www.nsf.org. After installation and routine maintenance, your water should be tested to ensure that the system is removing arsenic.

Drill a New Well

A new well installed at a different location or depth may or may not provide water with acceptable levels of arsenic. However, it is an option that may be worth pursuing in some situations.

Connect to a Public Water Supply or Community Well

It may be possible to connect to a public water supply or community well if one is nearby. These water systems must be maintained regularly and meet federal and state public health standards. Contact your local water utility to ask about the possibility of connecting to a public supply.

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