Health Consultation

Lake Roosevelt, Review of the Drinking Water System Northeast, Washington

October 15, 2012

Prepared by

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

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Foreword

The Washington State Department of Health (DOH) has prepared this health consultation in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous wastes. This report was supported by funds through a cooperative agreement with ATSDR. It was completed in accordance with approved methodologies and procedures existing at the time the health consultation was initiated. Editorial review was completed by DOH.

The purpose of this health consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on specific health issues so that DOH can respond to requests from concerned residents or agencies for health information on hazardous substances. DOH evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time of this health consultation, and should not necessarily be relied upon if site conditions or land use changes in the future.

For additional information or questions regarding DOH or the contents of this health consultation, please call the health advisor who prepared this document:

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

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: www.atsdr.cdc.gov .

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Summary

Introduction:
The northern reach of the Columbia River (Upper Columbia River) includes Franklin D. Roosevelt Lake (Lake Roosevelt). For the purpose of this health consultation, Lake Roosevelt and the Upper Columbia River are treated as a contiguous site (Lake Roosevelt). In the Lake Roosevelt community, Washington State Department of Health's (DOH) top priority is to ensure that the community has the best information possible to safeguard its health. DOH has prepared this health consultation at the request of the U.S. Environmental Protection Agency (EPA).

Conclusion:
DOH reached an important conclusion about three drinking water systems that withdrew water in the past (Grand Coulee Dam, City of Grand Coulee Water Department, and Coulee Dam Water Department) and the one system that is currently withdrawing water (Coulee Dam Water Department) from Lake Roosevelt in northeast Washington.

DOH concludes that using water from the three drinking water systems for drinking, showering, bathing, and cooking is not expected to cause health effects.

Basis for Decision:
The maximum concentrations of all contaminants of concern in this exposure scenario are below levels known to result in non-cancer health effects. Similarly, the level of bromodichloromethane and dibromochloromethane in drinking water falls within the EPA acceptable range for cancer risk.

Next steps:

1. DOH strongly advises against the use of untreated surface water as a drinking water source anywhere in the state.

2. DOH will mail this health consultation to the three water systems, and the local health districts and departments in the area.

3. If requested, DOH will review and evaluate any new data regarding contaminants in drinking water from Lake Roosevelt.

4. DOH has established community repositories for the public health consultation and related fact sheets.

For More Information:
Please feel free to contact Lenford O'Garro at 360-236-3376 or 1-877-485-7316 if you have any questions about this health consultation. Additionally, for surface water information visit DOH

website at:
http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/SourceWater/SurfaceWaterFAQ.aspx or fact sheet Questions and Answers (Q&A) regarding surface water:
http://www.doh.wa.gov/Portals/1/Documents/Pubs/331-207.pdf.

Statement of Issues

DOH has prepared this health consultation at the request of the U.S. Environmental Protection Agency (EPA). The purpose of this health consultation is to evaluate potential human health hazards posed by contaminants detected in surface water used as drinking water drawn from Lake Roosevelt by public water systems in northeast Washington. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

This health consultation is a current and historical review (9/1978 – 11/2011) of DOH's database for drinking water systems (Sentry)[a]. The database documents three drinking water systems (Grand Coulee Dam[b], City of Grand Coulee Water Department[c], and Coulee Dam Water Department[d]) that obtain surface water from Lake Roosevelt or did so in the past.

DOH strongly advises against the use of untreated surface water as a drinking water source, whether that source is Lake Roosevelt or other streams, lakes, and rivers. Water that is open to the atmosphere and vulnerable to surface water runoff is not safe to drink without complete treatment. Surface water sources are open to contamination from human and animal waste and other pollution. Consequently, they are particularly susceptible to contamination by organisms such as bacteria, viruses, and parasites that can cause serious illness and disease. Without extensive treatment provisions, water from Lake Roosevelt should not be used for a drinking water source. It is important to note that the three water systems in this health consultation have treatment systems in place.

Background

The Columbia River flows from British Columbia, Canada, southwards through eastern Washington and west to the Pacific Ocean. Construction of Grand Coulee Dam on the upper portion of the Columbia River created Lake Roosevelt, which is about 135 miles long [1]. The Columbia River contributes about 90% of water flowing into Lake Roosevelt [1].

Smelting and mining activities in British Columbia, northeast Washington, and Idaho have left a legacy of contaminated byproducts (e.g., slag and tailings) along the beaches and in Lake Roosevelt. In August 1999, the Confederated Tribes of the Colville Reservation (Colville Tribes) petitioned the EPA to assess human health and environmental risk of the Upper Columbia River (UCR) [2]. In 2001, EPA conducted an expanded site inspection. EPA determined a Remedial Investigation/Feasibility Study (RI/FS) was necessary to evaluate human health and environmental risks of the UCR due to widespread contamination in lake and river sediments

[a] DOH Sentry Internet data: http://www.doh.wa.gov/ehp/dw/sentry.htm

[b] DOH Water System Identification Number: 286958

[c] DOH Water System Identification Number: 28700F

[d] DOH Water System Identification Number: 15400V

from the U.S. - Canada border to Lake Roosevelt [3]. Over the years, a number of studies were conducted on Lake Roosevelt's water, sediments, and fish. These studies showed various contaminants, including heavy metals, dioxins/furans, and polychlorinated biphenyls (PCBs) [4, 5, 6, 7, 8, 9, 10].

The Grand Coulee Dam is a Group A, non-transient non-community (NTNC) water system with a sand filter and disinfection added as treatment to the surface water that supplied drinking water for workers and visitors at Grand Coulee Dam. A Group A non-community system serves twenty-five or more of the same non-residents per day for one hundred eighty days or more per year. Currently, Grand Coulee Dam intake from Lake Roosevelt is inactive. Water is now obtained from Electric City's groundwater well field.

The City of Grand Coulee Water Department is a Group A community system with disinfection added as treatment to the surface water. The City of Grand Coulee Water Department intake from Lake Roosevelt is also inactive. Water is also now obtained from Electric City's groundwater well field.

The Coulee Dam Water Department is also a Group A community system with disinfection added as treatment to the surface water. Coulee Dam Water Department is the only one of the three systems currently obtaining water from Lake Roosevelt.

Table 1. Compounds detected in Grand Coulee Dam (9/1991 - 12/15/2010) surface drinking water system from Lake Roosevelt in northeast Washington.

Compounds	Maximum Concentration (ppb)	Comparison Value (ppb)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Barium	33	2000	CN	EMEG	No
Mercury	0.2	2*	C	MCL	No
Chloride	26,000	250,000		MCL	No
Cyanide	13	200	D	LTHA	No
Fluoride	6,000	4,000		MCL	Yes
Zinc	21	3,000	IN	EMEG	No
Copper	39	1,300	D	MCLG	No
Iron	106	300		SMCL	No
Manganese	14	500	D	RMEG	No
Nitrate	7,090	10,000		MCL	No
Sodium	10,400				No†
Sulfate	10,800	250,000		MCL	No
Hexachlorocyclopentadiene	0.1	50	NO	MCL	No
Haloacetic Acids (HAA_5)	34	60		MCL	No
Total Trihalomethane (THM)	41.6	80		MCL	No
Bromoform	1.5	4	B2	CREG	No††
Chloroform	40.1	100		EMEG	No††
Bromodichloromethane	1.5	200 0.6	B2	EMEG CREG	No Yes††

RMEG - ATSDR's Reference Dose Media Evaluation Guide (child)
EMEG - ATSDR's Environmental Media Evaluation Guide (child)
C - EPA: Possible human carcinogen (no human, limited animal studies)
CN - Carcinogenic potential cannot be determined
D - EPA: Not classifiable as to health carcinogenicity
* Inorganic mercury MCL value was used as a surrogate
LTHA = EPA's Lifetime Health Advisory for Drinking Water
MCL = Maximum contaminant level - Federal and state drinking water standard
MCLG = Maximum contaminant level goal - Federal and state drinking water standard
SMCL = Secondary Maximum contaminant level - Federal and state drinking water standard
† - See Public Health Implications section
NO - Not likely to be carcinogen to humans
IN - Inadequate information to assess carcinogenic potential
ppb - parts per billion
†† - See Total trihalomethane section (sum of disinfection by-products)
HAA_5 - Haloacetic Acids (disinfection by-products)
EPA - Environmental Protection Agency

Table 2. Compounds detected in City of Grand Coulee Water Department (5/1/1989 – 3/24/2006) surface drinking water system from Lake Roosevelt in northeast Washington.

Compounds	Maximum Concentration (ppb)	Comparison Value (ppb)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Barium	30	2,000	CN	EMEG	No
Calcium	20,200				No†
Chloride	19,000	250,000		MCL	No
Fluoride	2,000	4,000		MCL	No
Copper	13.8	1,300	D	MCLG	No
Iron	101	300		SMCL	No
Magnesium	5,080				No†
Manganese	20	500	D	RMEG	No
Nitrate	1,300	10,000		MCL	No
Sodium	4,540				No†
Sulfate	96,900	250,000		MCL	No
Total Trihalomethane (THM)	75.7	80		MCL	No
Chloroform	74	100		EMEG	No††
Bromodichloromethane	1.7	200 0.6	B2	EMEG CREG	No Yes††
Haloacetic Acids (HAA_5)	25.8	60		MCL	No
Tetrachloroethylene	1.4	5	C	MCL	No
M/P - Xylenes	0.7	2,000	IN	EMEG	No
Lead	20	15*	B2	MCL*	No
Radium 228	1.52**	5**		MCL	No

RMEG - ATSDR's Reference Dose Media Evaluation Guide (child)
EMEG - ATSDR's Environmental Media Evaluation Guide (child)
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
C - EPA: Possible human carcinogen (no human, limited animal studies)
CN - Carcinogenic potential cannot be determined
D - EPA: Not classifiable as to health carcinogenicity
ppb - parts per billion
* = Federal and state drinking water standard – MCL action level is 15 ppb if 10% of sample is exceeded (One sample only).
**= pico Curies per Liter (pCi/L)
MCL = Maximum contaminant level - Federal and state drinking water standard
MCLG = Maximum contaminant level goal - Federal and state drinking water standard
SMCL = Secondary Maximum contaminant level - Federal and state drinking water standard
† - See Public Health Implications section
IN - Inadequate information to assess carcinogenic potential
†† - See Total trihalomethane section (sum of disinfection by-products)
HAA_5 - Haloacetic Acids (disinfection by-products)
EPA - Environmental Protection Agency

Table 3. Compounds detected in Coulee Dam Water Department (9/1978 – 11/21/2011) surface drinking water system from Lake Roosevelt in northeast Washington.

Compounds	Maximum Concentration (ppb)	Comparison Value (ppb)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern (COC)
Antimony	7	6	D	MCL	Yes
Barium	28.3	2,000	CN	EMEG	No
Mercury	1	2*	C	MCL	No
Calcium	21,100				No†
Chloride	6,000	250,000		MCL	No
Fluoride	1,400	4,000		MCL	No
Zinc	8.8	3,000	IN	EMEG	No
Copper	192	1,300	D	MCLG	No
Iron	661	300		SMCL	No†
Magnesium	4,900				No†
Manganese	18	500	D	RMEG	No
Nitrate	200	10,000		MCL	No
Selenium	2.3	50	D	EMEG	No
Sodium	7,000				No†
Sulfate	10,000	250,000		MCL	No
Total Trihalomethane (THM)	66.94	80		MCL	No
Chloroform	64.1	100		EMEG	No††
Bromoform	0.8	4	B2	CREG	No††
Bromodichloromethane	5.9	200 0.6	B2	EMEG CREG	No Yes††
Dibromochloromethane	4.9	900 0.4	B2	EMEG CREG	No Yes††
Haloacetic Acids (HAA_5)	32	60		MCL	No
M/P - Xylenes	2.4	2,000	IN	EMEG	No
O- Xylene	0.9	2,000	IN	EMEG	No
Ethylbenzene	0.6	700	D	MCL	No
Radium 228	2.14**	5**		MCL	No
Gross Beta	2**	50**		EPA***	No
Silica	3,000				No†

EPA - Environmental Protection Agency
RMEG - ATSDR's Reference Dose Media Evaluation Guide (child)
EMEG - ATSDR's Environmental Media Evaluation Guide (child)
C - EPA: Possible human carcinogen (no human, limited animal studies)
CN - Carcinogenic potential cannot be determined
D - EPA: Not classifiable as to health carcinogenicity
ppb -parts per billion
*= Inorganic mercury MCL value was used as a surrogate
**= pico Curies per Liter (pCi/L)
***EPA - screening tool for Gross Beta
MCL = Maximum contaminant level - Federal and state drinking water standard
SMCL = Secondary Maximum contaminant level - Federal and state drinking water standard

MCLG = Maximum contaminant level goal - Federal and state drinking water standard
† - See Public Health Implications section
IN - Inadequate information to assess carcinogenic potential
†† - See Total trihalomethane section (sum of disinfection by-products)
HAA_5 - Haloacetic Acids (disinfection by-products)

Discussion

Data Analysis

One of the criteria in reviewing the state's Sentry water system database[e] for this health consultation was that the water source had to be Lake Roosevelt. Therefore, no blended water or other water sources (wells) were considered in this review. Water quality results from water systems are entered into the database as follows: If there is a true detection of a compound, the result range had an EQ (equal) next to it; if there is not a detection of a compound, the result range had LT (less than) next to the laboratory reporting limit; and if a compound was not tested, it is coded NA (not applicable). Only compounds with an EQ were evaluated in this report.

There were 143 records reviewed for the Grand Coulee Dam. Analyte group identification consisted of disinfection by products (DBP), inorganic compounds (IOC), radionuclides (RAD), synthetic organic compounds (SOC), and volatile organic compounds (VOC). Similarly, there were 146 records reviewed for the City of Grand Coulee Water Department. Analyte group identification consisted of DBP, IOC, RAD, SOC, and VOC. Additionally, there were 339 records reviewed for the Coulee Dam Water Department. Analyte group identification consisted of DBP, IOC, RAD, SOC, and VOC. Tables 1, 2, and 3, summarize compounds found in the three water systems for specified dates.

Contaminants of Concern

DOH determined contaminants of concern (COC) in drinking water by employing a screening process. Maximum drinking water contaminant levels were screened against health-based drinking water comparison values. Several types of health-based comparison or screening values were used during this process [see the glossary for a description of "comparison value"] including the ATSDR reference dose media evaluation guide (RMEG), environmental media evaluation guide (EMEG), and cancer risk evaluation guide (CREG). Other screening values included the EPA maximum contaminant goals (MCLGs), primary and secondary maximum contaminant levels (MCLs and SMCLs, respectively), and lifetime health advisories for drinking water (LTHA).

Comparison values offer a high degree of protection and assurance that people are unlikely to be harmed by contaminants in the environment. For chemicals that cause cancer, the comparison values represent levels that are calculated to increase the estimated risk of cancer by about one additional cancer in one million people exposed. These types of comparison values often form the basis for cleanup. In general, if a contaminant's maximum concentration is greater than its comparison value, then the contaminant is evaluated further.

[e] DOH Sentry Internet data: http://www.doh.wa.gov/ehp/dw/sentry.htm

Five compounds (antimony, fluoride, iron, bromodichloromethane, and dibromochloromethane) in the drinking water systems exceed comparison values (see Tables 1, 2, and 3). However, only four of the compounds (antimony, fluoride, bromodichloromethane and dibromochloromethane) are considered to be COCs. Although iron exceeds the comparison value, it is not considered a COC. None of the water systems exceeded the drinking water standard for total trihalomethanes (THMs). However, two individual THM by-products (bromodichloromethane and dibromochloromethane) exceeded their CREG and will be further evaluated.

Iron, along with calcium, magnesium, sodium, and silica (which had no comparison values) are discussed in the Public Health Implications section. None of the COCs are carcinogens; therefore, only non-cancer hazards will be evaluated.

Exposure Pathways

In order for any contaminant to be a human health concern, the contaminant must be present at a high enough concentration to cause potential harm, and there must be a completed route of exposure to people. That is, exposure to contaminants in the drinking water where someone is or has swallowed (ingestion exposure), breathed (inhalation exposure), or had contact with their skin (dermal exposure) would be a completed route of exposure. Antimony and fluoride are COC's, and both are inorganic compounds that are soluble in water. The most obvious route of past exposure was ingestion of drinking water by residents, workers, and visitors. However, past exposure to antimony and fluoride may have occurred through dermal contact, particularly during bathing and showering. Inhalation from water or indoor air during bathing, showering, or cooking was unlikely because antimony and fluoride are not volatile. Past exposure to inorganic compounds of concern through these routes and pathways are evaluated below.

Similarly, bromodichloromethane and dibromochloromethane are organic compounds and exposure routes are through ingestion of drinking water, dermal contact during bathing and showering, and inhalation from water or indoor air during bathing, showering, or cooking.

Public Health Implications

Calcium, Magnesium, Sodium

Calcium, magnesium, and sodium are essential nutrients and are typically not harmful under most environmental exposure scenarios [11]. Therefore, no public health standards have been established for calcium and magnesium in drinking water. The EPA has established a drinking water equivalency level or guidance level for sodium of 20 milligrams per liter (mg/L). However, EPA believes the guidance level for sodium needs updating and is probably low [11]. The Institute of Medicine has established Dietary Reference Intakes for elements [12]. DOH calculated an average daily intake for calcium, magnesium, and sodium by multiplying the maximum level of the element in water by the amount of water ingested per day 1.4 liters. This was then compared to the Dietary Reference Intakes for that element.

Calcium

The maximum level of calcium detected in the drinking water systems was 21,100 parts per billion (ppb) or 21.1 mg/L. In a worst-case scenario, a person exposed to the maximum level of calcium in the water and drinking 1.4 liters of water a day would obtain 29.5 mg/day of calcium. The Adequate Intakes for calcium from the Dietary Reference Intakes table range from 210 - 1,300 mg/day, depending on age and gender [12].

Magnesium

The maximum level of magnesium detected in the drinking water systems was 5,080 ppb or 5.08 mg/L. In a worst-case scenario, a person exposed to the maximum level of magnesium in the water who drinks 1.4 liters of water a day would obtain 7.1 mg/day of magnesium. The Recommended Dietary Allowances for magnesium from the Dietary Reference Intakes table range from 80 - 420 mg/day, depending on age and gender [12].

Sodium

The maximum level of sodium detected in the drinking water systems was 10,400 ppb or 10.4 mg/L. In a worst-case scenario, a person exposed to the maximum level of sodium in the water and drinking 1.4 liters of water a day, would obtain 14.6 mg/day of sodium. The Adequate Intakes for sodium from the Dietary Reference Intakes table range from 120 – 1,500 mg/day, depending on age and gender [12].

Calcium, magnesium, and sodium are essential nutrients. Concentrations of these chemicals are well below levels expected to cause health effects and will not be evaluated further.

Silica

Silica and its various forms are abundant in nature. Dissolved silica in natural water may range from 3,800 – 363,000 ppb or 3.8 - 363 mg/L [13]. Silica is naturally present in municipal drinking water at about 8,000 ppb or 8 mg/L [14]. Silica is considered “Generally Regarded As Safe (GRAS)” by the Food and Drug Administration (FDA) [13, 14]. The maximum level of silica detected in the drinking water systems was 3,000 ppb or 3.0 mg/L. ATSDR has not derived a minimal risk level (MRL) for silica and EPA has not established an oral reference dose (RfD) for silica. The National Sanitary Foundation (NSF) has established a single product allowable concentration (SPAC) for silicate at 16,000 ppb or 16 mg/L [15]. Since the FDA considers silica as GRAS, the NSF SPAC for silica is not exceeded, and silica is common in drinking water at 8,000 ppb or 8 mg/L. DOH does not expect silica in the drinking water system to cause health effects, and it will not be evaluated any further.

Iron

Secondary maximum contaminant levels (SMCL) are established by EPA as guidelines to assist public water systems in managing drinking water for taste, color, and odor and are not considered a threat to human health. Over the period from 9/1978 to 11/21/2011, one historical iron sample exceeded the SMCL. DOH does not expect iron in the drinking water system to cause health effects, and it will not be evaluated any further.

Chemical-Specific Toxicity

Evaluating Non-cancer Hazards

Exposure assumptions for estimating antimony and fluoride exposures for water taken from Lake Roosevelt are found in Appendix A, Table A1. In order to evaluate the potential for non-cancer adverse health effects that may result from exposure to contaminated media (i.e., soil, air, and water), a dose is estimated for each COC. These doses are calculated for situations (scenarios) in which a person might be exposed to the contaminated media. The estimated dose for each contaminant under each scenario is then compared to the MRL. MRLs are an estimate of the daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during a specified duration of exposure. In the absence of MRLs, DOH uses EPA's RfD. RfDs are doses below which non-cancer adverse health effects are not expected to occur. MRLs and/or RfDs are derived from toxic effect levels obtained from human population and laboratory animal studies. These toxic effect levels can be either the lowest-observed adverse effect level (LOAEL) or the no-observed adverse effect level (NOAEL). In human or animal studies, the LOAEL is the lowest dose at which an adverse health effect is seen, while the NOAEL is the highest dose that does not result in any adverse health effects.

Because of uncertainty in these data, the toxic effect level is divided by "uncertainty factors" to produce the lower and more protective MRL or RfD. If a dose exceeds the MRL or RfD, it does not mean that adverse health effects will occur. When the MRL or RfD is exceeded, further toxicological evaluation is needed. The further evaluation includes comparing the site-specific estimated dose to doses from animal and human studies that showed either an effect level or a no effect level. This comparison, combined with other toxicological information, such as sensitive groups and chemical metabolism, is used to determine the risk of specific harmful effects. A MRL or RfD is exceeded whenever the hazard quotient (HQ) is greater than one (see Appendix A for the hazard quotient equation).

Estimated exposure doses, exposure assumptions, and hazard quotients are presented in Appendix A for antimony and fluoride found in water taken from Lake Roosevelt. Based on exposure estimates quantified in Appendix A, residents or workers are not likely to experience adverse non-cancer health effects from exposure to antimony and fluoride in water taken from Lake Roosevelt since the exposure dose does not exceed the MRL or RfD.

Antimony

Antimony entering the body from drinking water will move to the blood. Then most of the antimony goes to the liver, lungs, intestines, and spleen and slowly leaves the body in urine and feces [16]. Animal studies have shown that long-term exposure to low levels of antimony can cause slight changes in the liver, increased cholesterol, and decreased glucose in blood. However, there are no human data for long-term exposure to low levels of antimony.

Antimony was detected at a maximum concentration of 7 ppb in the Coulee Dam Water Department drinking water system. Over the period from 1978 to 2011, one historical antimony sample exceeded the drinking water MCL (6 ppb) standard. This maximum level of antimony in the drinking water system also exceeds the ATSDR chronic RMEG (4 ppb) for children. ATSDR

has not derived an MRL for antimony. However, the EPA has established an RfD for antimony of 0.0004 mg/kg/day.

Estimated exposure doses for children and adults were calculated with resulting exposure doses ranging from 0.00023 to 0.0000647 mg/kg/day (see Appendix A, Table A2). These exposure doses are less than the RfD, the NOAEL (0.0748 mg/kg/day) for intermediate exposure, and the LOAEL (0.262 mg/kg/day) for chronic exposure to antimony. Therefore, DOH does not expect that exposures to antimony will cause harmful non-cancer health effects.

Fluoride

Fluoride is added to drinking water systems for reducing and preventing tooth decay thereby improving the community's health. However, the main health concern regarding fluoride is likely to be from excessive chronic oral exposure in drinking water. The primary target system for intermediate and chronic exposures of both humans and several laboratory animal species is the skeletal system (including teeth) [17]. This is due to the deposition of significant amounts of fluoride in bone.

The maximum level of fluoride detected in Grand Coulee Dam drinking water system was 6,000 ppb or 6 mg/L. Grand Coulee Dam is a NTNC system, and it is not expected to be the major source of water for visitors (adults or children). Therefore, only workers' exposure will be evaluated. Over the period from 1991 to 2010, one historical fluoride sample exceeded the drinking water MCL (4,000 ppb or 4 mg/L) standard. ATSDR has derived a MRL of 0.05 mg/kg/day for sodium fluoride. However, the EPA has established an RfD for fluoride of 0.06 mg/kg/day. In a worst-case scenario, a worker exposed to the maximum level of fluoride in drinking water and drinking 1.4 liters of water a day, would obtain 8.4 mg/day of fluoride. The Adequate Intakes for fluoride from the Dietary Reference Intakes table range from 0.7 - 4 mg/day, depending on age and gender [12]. However, the upper tolerable intake level in food for older children and adults is 10 mg/day.

An estimated exposure dose for workers was calculated and is 0.0108 mg/kg/day (see Appendix A, Table A2). This exposure dose is less than the RfD for chronic exposure to fluoride. Therefore, DOH does not expect that exposures to workers from fluoride will cause harmful non-cancer health effects.

Total Trihalomethane

Trihalomethanes (THMs) are a group of chemicals formed as by-products of chemical disinfection used to kill bacteria in water systems. Chlorine, chloramines, and bromine are the most common chemical disinfectants used in water systems. THMs are formed when chlorine or bromine chemically bond with naturally occurring organic matter in the water system. Total THMs consist of bromodichloromethane, bromoform, chloroform, and dibromochloromethane. In addition to THMs, other types of by-products are formed, including haloacetic acids [18]. The EPA and State drinking water standard for total THMs is 80 ppb. None of the water systems exceeded the drinking standard for total THMs. However, two of the individual by-products (bromodichloromethane and dibromochloromethane) exceeded their CREG and are evaluated further.

Bromodichloromethane

Bromodichloromethane is a colorless, very volatile, nonflammable liquid. Most people are exposed to bromodichloromethane by drinking chlorinated water. Animal studies show that exposure to bromodichloromethane affect the liver, kidney, and central nervous system [19]. However, human health effects were not seen in people exposed to bromodichloromethane [19].

Bromodichloromethane was detected at a maximum concentration of 5.9 ppb in the Coulee Dam Water Department drinking water system. Over the period from 1978 to 2011, the average concentration was 1.7 ppb. Since the maximum concentration of bromodichloromethane did not exceed the ATSDR chronic EMEG (200 ppb) for children, DOH does not expect exposures to bromodichloromethane to cause harmful non-cancer health effects.

Dibromochloromethane

Dibromochloromethane is a colorless to yellow, very volatile, nonflammable liquid, with a sweet odor. Most people are exposed to dibromochloromethane by drinking chlorinated water. Animal studies show that liver and kidney cancer occurs from exposure to dibromochloromethane [20]. However, no conclusive studies have shown cancer in humans. No studies regarding health effects in humans or animals from dermal exposure to dibromochloromethane were found [20].

Over the period from 1978 to 2011, there were only three historical samples in the Coulee Dam Water Department drinking water system where dibromochloromethane was detected. The maximum concentration was 4.9 ppb. Since the maximum concentration of dibromochloromethane did not exceed the ATSDR chronic EMEG (900 ppb) for children, DOH does not expect exposures to dibromochloromethane to cause harmful non-cancer health effects.

Evaluating cancer hazards

Some chemicals have the ability to cause cancer. Cancer risk is estimated by calculating a dose similar to those used for evaluating non-cancer hazards and multiplying it by a cancer potency factor, also known as the cancer slope factor. Some cancer potency factors are derived from human population data. Others are derived from laboratory animal studies involving doses much higher than are encountered in the environment. Use of animal data requires extrapolation of the cancer potency obtained from these high dose studies down to real-world exposures. This process involves much uncertainty.

Current regulatory practice assumes there is no “safe dose” of a carcinogen and that any dose of a carcinogen will result in some additional cancer risk. Therefore, estimated cancer risk estimates are not yes/no answers, but measures of chance (probability). Such measures, however uncertain, are useful in determining the magnitude of a cancer threat because any level of a carcinogenic contaminant carries an associated risk. The validity of the “no safe dose” assumption for all cancer-causing chemicals is not clear. Some evidence suggests that certain chemicals considered to be carcinogenic must exceed a threshold of tolerance before initiating cancer. For such chemicals, risk estimates are not appropriate. Recent guidelines on cancer risk from EPA reflect the potential that thresholds for some carcinogenesis exist. However, EPA still assumes no threshold unless sufficient data indicate otherwise [21].

This document describes estimated cancer risk that is attributable to site-related contaminants in qualitative terms like low, very low, slight, and no significant increase in estimated cancer risk. These terms can be better understood by considering the population size required for such an estimate to result in a single cancer case. For example, a low increase in cancer risk indicates an estimate in the range of one cancer case per ten thousand persons exposed over a lifetime. A very low estimate might result in one cancer case per several tens of thousands exposed over a lifetime, and a slight estimate would require an exposed population of several hundreds of thousands to result in a single case. DOH considers estimated cancer risk insignificant when the estimate results in less than one cancer per one million exposed over a lifetime. The reader should note that these estimates are for excess cancers that might result in addition to those normally expected in an unexposed population.

Estimated Cancer Risk

Estimated cancer risk does 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 excess cancers expected in 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

Cancer is a common illness and its occurrence in a population increases with the age of the population. There are many different forms of cancer resulting from a variety of causes; not all are fatal. Approximately 1 in 3 to 1 in 2 people living in the United States will develop cancer at some point in their lives [22].

DOH also calculated estimated cancer risk based on exposure doses (Appendix A). Exposure to bromodichloromethane in drinking water would increase a person's estimated cancer risk by about 1 in 1,000,000 (1 excess cancer in a population of 1,000,000 similarly exposed people) (See Appendix A - Table A3). Exposure to dibromochloromethane in drinking water would increase a person's estimated cancer risk by about 7 in 10,000,000 (7 excess cancers in a population of 10,000,000 similarly exposed people) (See Appendix A - Table A3).

The sum of exposure to bromodichloromethane and dibromochloromethane in drinking water would increase a person's lifetime estimated cancer risk by about 2 in 1,000,000 (2 excess cancers in a population of 1,000,000 similarly exposed people) (See Appendix A - Table A3). It should be noted that this estimate is for excess cancers that may result in addition to those that would normally occur in an unexposed population. This estimated risk is slight and within the range of cancer risks (1 in 10,000 to 1 in 1,000,000) considered acceptable by the EPA [23, 24].

Children's Health Considerations

The potential for exposure and subsequent adverse health effects often increases for younger children compared with older children or adults. ATSDR and DOH recognize that children are

susceptible to developmental toxicity that can occur at levels much lower than those causing other types of toxicity. The following factors contribute to this vulnerability:

- 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 the writing of this health consultation and the exposure scenarios treated children as the most sensitive population being exposed. The doses calculated for the COCs are not expected to result in adverse health effects for children or adults based on comparison with MRL or RfD value.

Conclusions

DOH concludes that using water from the three drinking water systems in the past (Grand Coulee Dam, City of Grand Coulee Water Department, and Coulee Dam Water Department) or currently as in the case of Coulee Dam Water Department for drinking, showering, bathing, and cooking is not expected to harm people's health. The maximum concentrations of all contaminants of concern in this exposure scenario are below levels known to result in non-cancer health effects. Similarly, bromodichloromethane and dibromochloromethane in drinking water falls within the EPA acceptable range for cancer risk.

Recommendations

DOH strongly advises against the use of untreated surface water as a drinking water source anywhere in the state.

Public Health Action Plan

Action Planned

1. DOH will mail this health consultation to the three water systems, and the local health districts and departments in the area.
2. If requested, DOH will review and evaluate any new data regarding contaminants in drinking water from Lake Roosevelt.
3. DOH has established community repositories for the public health consultation and related fact sheets at the following:
    - Northport: Northport Town Hall, 315 Summit Street, 509-732-4450
    - Colville: Colville Public Library, 195 South Oak Street, 509-684-6620
    - Inchelium: Inchelium Tribal Resource Center, 12 Community Loop, 509-634-2791

- Nespelem: Office of Environmental Trust, Building #2, Colville Confederated Tribes, 1 Colville, 509-634-2413
- Grand Coulee: Grand Coulee Library, 225 Federal Street, 509-633-0972
- Wellpinit: Spokane Tribe Department of Natural Resources, 6290 B Ford-Wellpinit Road, 509-258-7709 extension 13
- Spokane: Spokane Library, 906 West Main Avenue, 509-444-5336

Report Preparation

This Health Consultation for the Upper Columbia River/Lake Roosevelt site was prepared by the Washington State Department of Health 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, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

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Appendix A

This section provides calculated exposure doses and assumptions used for exposure to chemicals in water from Lake Roosevelt. Three different exposure scenarios were developed to model exposures that might occur. These scenarios were devised to represent exposures to a child (0-5 years), an older child, and an adult. The following exposure parameters and dose equations were used to estimate exposure doses from direct contact with chemicals in water.

Exposure to inorganic contaminants in water via ingestion and dermal absorption

Total dose $_{\text{(non-cancer)}}$ = Ingested Dose + Dermally Absorbed Dose

Ingestion Route

$$\text{Dose}_{\text{(non-cancer (mg/kg-day))}} = \frac{Cw \times CF \times IR \times EF \times ED}{BW \times AT_{\text{non-cancer}}}$$

$$\text{Dose}_{\text{(cancer (mg/kg-day))}} = \frac{Cw \times CF \times IR \times EF \times ED}{BW \times AT_{\text{cancer}}}$$

$$\text{Cancer Risk} = \frac{Cw \times IR \times EF \times ED \times CSF}{BW \times AT_{\text{cancer}}} \text{ or Dose}_{\text{(cancer (mg/kg-day))}} \times CSF$$

Dermal Route - (Shower)

$$\text{Dermal Absorbed } (DA_{event}) = \frac{2 \times Kp \times Cw \times SqR \text{ of } 6 \times tau \times t/pi}{ORAF}$$

$$\text{Dermal Absorbed Dose (DAD)}_{\text{(non-cancer (mg/kg-day))}} = \frac{DA_{event} \times EV \times SA \times EF \times ED}{BW \times AT_{\text{non-cancer}}}$$

$$\text{Dermal Absorbed Dose (DAD)}_{\text{(cancer (mg/kg-day))}} = \frac{DA_{event} \times EV \times SA \times EF \times ED}{BW \times AT_{\text{cancer}}}$$

$$\text{Cancer Risk} = \frac{DA_{event} \times EV \times SA \times EF \times ED \times CSF}{BW \times AT_{\text{cancer}}} \text{ or DAD}_{\text{(cancer (mg/kg-day))}} \times CSF$$

Inhalation Route – (Shower)

$$\text{Concentration in air (Ca)} = S/R \times (1 - (EXP\ (-R \times t)))$$

$$\text{Dose}_{\text{cancer (mg/kg-day)}} = \frac{Ca \times IHR \times EF \times ED}{BW \times AT_{\text{cancer}}}$$

$$\text{Cancer Risk} = \frac{Ca \times IHR \times EF \times ED \times CSF}{BW \times AT_{\text{cancer}}} \text{ or Dose}_{\text{cancer}} \times CSF$$

Table A1. Exposure assumptions used to estimate drinking water dose exposure from Lake Roosevelt in northeast Washington.

Parameter	Value	Unit	Comments
Concentration (Cw)	Variable	µg/L	Maximum detected value
Conversion Factor (CF)	0.001	µg/mg	Converts contaminant concentration from micrograms(µg) to milligrams (mg)
Ingestion Rate (IR) - adult	1.4	L/day	Exposure Factors Handbook [25]
Ingestion Rate (IR) - older child	1.0		
Ingestion Rate (IR) - child	0.9		
Exposure Frequency (EF)	350	days/year	Daily exposure minus two week vacation – Antimony, dibromochloromethane, bromodichloromethane
	250		Adult worker - Average working days per year – Fluoride
Exposure Duration (ED)	Variable	years	Antimony – 1 year * Fluoride – 1.58 years* Dibromochloromethane - 1.25 years* Bromodichloromethane – (30 years (5, 10,15) (child, older child, adult yrs))
Body Weight (BW) - adult	72	kg	Adult mean body weight
Body Weight (BW) - older child	41		Older child mean body weight
Body Weight (BW) - child	15		0-5 year-old child average body weight
Surface Area (SA) - adult	20000	cm^2	Exposure Factors Handbook [25]
Surface Area (SA) - older child	11800		
Surface Area (SA) - child	6640		
Averaging $Time_{non\text{-}cancer}$ (AT) child	1825	days	5 years
Averaging $Time_{non\text{-}cancer}$ (AT) older child	3650	days	10 years
Averaging $Time_{non\text{-}cancer}$ (AT) adult	5475	days	15 years
Averaging $Time_{cancer}$ (AT)	27375	days	75 years
Time per shower (t)	0.25	hr/event	Source: EPA [26]
Event frequency (EV)	1	unitless	events/day
pi	3.14	unitless	Model Parameters [27]
Oral route adjustment factor (ORAF)	1	unitless	Non-cancer (nc) / cancer (c) - default
Dermally absorbed dose per event (DA_{event})	Variable	mg/cm^2	Source: EPA [26]
Dermally absorbed dose (DAD)	Variable	mg/kg-day	Source: EPA [26]
Skin permeability coefficients (Kp)	Variable	cm/hr	Chemical specific: Bromodichloromethane – 0.0035 Dibromochloromethane – 0.0046
Lag time (tau)	Variable	hr	Chemical specific: Bromodichloromethane – 0.87 Dibromochloromethane – 1.57
Inhalation rate (IHR) - adult	0.158	m^3/day	Exposure Factors Handbook [25]
Inhalation rate (IHR) - older child	0.146		
Inhalation rate (IHR) - child	0.086		
Air exchange rate (R)	0.0083	min^{-1}	Model Parameters [27]
Time concentration calculated (t)	15	min	Model Parameters [27]
Inhalation exposure for shower (Exp)	Variable	µg/shower	Model Parameters [27]
Concentration in air (Ca)	Variable	mg/m^3	Model Parameters [27] Bromodichloromethane – 1.17E-4 Dibromochloromethane – 3.80E-4

Shower emission rate (S)	Variable	mg/m^3-min	Model Parameters [27]

*period of time between MCL exceedance or sample maximum detection to follow-up sample
kg - kilogram
µg/L - microgram per liter
µg/mg - microgram per milligram
L/day - liter per day
cm^2 - square centimeter
hr/event - hour per event
mg/cm^2 - milligram per square centimeter
mg/kg/day - milligrams per kilogram body-weight per day
cm/hr - centimeter per hour
EPA - Environmental Protection Agency

Lake Roosevelt Drinking Water Exposure Route –Non-cancer

Table A2. Non-cancer hazard calculations resulting from exposure to inorganic contaminants in drinking water from Lake Roosevelt in northeast Washington (9/1978 – 11/21/2011)

Contaminant	**Maximum Concentration (ppb)**	**Scenarios**	**Estimated Dose** (mg/kg/day)		**Total Dose** (mg/kg/day)	**RfD** (mg/kg/day)	**Total Dose/ RfD**
			Ingestion	Dermal Contact			
Antimony	7	Child	8.05E-5	1.49E-4	2.30E-4	4.0E-4	0.58
		Older Child	1.64E-5	9.66E-5	1.13E-4		0.28
		Adult	8.70E-6	9.32E-5	1.02E-4		0.25
Fluoride	6000	Adult worker	8.42E-3	2.40E-3	1.08E-2	6.0E-2	0.32

ppb -parts per billion
RfD - EPA oral reference dose
mg/kg/day - milligrams per kilogram body-weight per day

Hazard Quotient formula:

$$HQ = \frac{\text{Estimated Dose (mg/kg-day)}}{\text{RfD (mg/kg-day)}}$$

Lake Roosevelt Drinking Water Exposure Route – Cancer

Table A3. Cancer hazard calculations resulting from exposure to bromodichloromethane and dibromochloromethane in drinking water from Lake Roosevelt in northeast Washington (9/1978 – 11/21/2011)

Contaminant	Maximum Concentration (ppb)	EPA Cancer Group	Scenarios	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Estimated Dose			Total Dose	Increased Cancer Risk			Total Cancer Risk
					Ingestion	Dermal Contact	Inhalation		Ingestion	Dermal Contact	Inhalation	
Bromodichloromethane	1.7*	B2	Child	6.2E -2** 1.3E-1***	6.52E-6	2.17E-7	4.32E-8	6.78E-6	4.04E-7	2.82E-8	5.61E-9	4.38E-7
			Older Child		5.30E-6	2.8E-7	5.33E-8	5.63E-6	3.29E-7	3.67E-8	6.92E-9	3.73E-7
			Adult		6.34E-6	4.1E-7	4.94E-8	6.80E-6	3.93E-7	5.31E-8	6.42E-9	4.53E-7
Dibromochloromethane	4.9	B2	Child	8.4E -2** 9.45E-2***	4.70E-6	2.76E-7	3.50E-8	5.01E-6	3.95E-7	2.32E-8	3.31E-9	4.22E-7
			Older Child		1.91E-6	1.8E-7	2.16E-8	2.11E-6	1.60E-7	1.5E-8	2.04E-9	1.77E-7
			Adult		1.52E-6	1.7E-7	1.33E-8	1.70E-6	1.28E-7	1.5E-8	1.26E-9	1.44E-7
Sum of Cancer Risks												2.01E-6

ppb – parts per billion
mg/kg/day - milligrams per kilogram body-weight per day
*Average concentration
**Cancer Potency for oral and dermal (EPA)
***Cancer Potency for inhalation based on inhalation unit risk converted to inhalation Cancer Potency (EPA)
EPA - Environmental Protection Agency
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)

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).
Carcinogen	Any substance that causes cancer.
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**].
Disinfection Byproducts (DBP)	Compounds formed when chlorine or other disinfectants used in water treatment plants react with bromide and/or natural organic matter (i.e., decaying vegetation) present in the source water.
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**].
Hazardous Substance	Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.
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/day for water, and 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.
Lifetime Health Advisories (LTHA)	A non-enforceable drinking water regulation established by the federal government. It provides guidance and information on contaminants not currently regulated.
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.
Maximum Contaminant Level Goal (MCLG)	A non-enforceable drinking water regulation established by the federal Safe Drinking Water Act. It is usually the starting point for determining 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.
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**].
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.
Radionuclides (RAD)	Naturally occurring or manmade radioactive contaminants.
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 RMEG is a *comparison value* used to select contaminants of potential health concern and is based on EPA's oral reference dose (RfD).

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**].
Secondary Maximum Contaminant Level (SMCL)	A non-enforceable drinking water regulation established by the federal Safe Drinking Water Act. It is based on aesthetics such as color, taste, and odor.
Surface Water	Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].
Synthetic Organic Compound (SOC)	Organic compounds that is manmade. SOCs include substances such as pesticides, polychlorinated biphenyls (PCBs), and dioxins.
Volatile Organic Compound (VOC)	Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.