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Revision 0

Native American Risk Assessment for the 100-FR-3 Groundwater Operable Unit

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company
P.O. Box 1600
Richland, Washington 99352

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S. Lindberg
Freestone Environmental, Inc.

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CH2MHILL
Plateau Remediation Company
P.O. Box 1600
Richland, Washington 99352

APPROVED
By Shauna Adams at 10:21 am, Nov 05, 2013

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Environmental Calculation Cover Page

Part 1: Completed by the Responsible Manager

Project: 100-FR-3 OU **Date: June 19, 2013**

Calculation Title & Description: Native American Risk Assessment for the 100-FR-3 Groundwater Operable Unit

This environmental calculation provides an evaluation of human health risk to Native Americans from exposure to contaminants in the 100-FR-3 Groundwater Operable Unit.

Preparer: Sara Lindberg	**Basis of Qualification: Education and Experience**
Checker: Linda Carr	**Basis of Qualification: Education and Experience**
Senior Reviewer: Donna Morgans	**Basis of Qualification: Education and Experience**

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Calculation No.: ECF-100FR3-11-0025 **Revision No.:** Rev. 0

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Rev. 0	Toxicity information was revised as applicable to be consistent with updated IRIS toxicity values as documented in EPA Regional Screening Level Table issued November 2012.	6/19/13	All

Part 3: Document Review & Approval:

Preparer:

Sara Lindberg/Environmental Chemist
NAME/POSITION

SIGNATURE — DATE 6/20/2013

Checker:

Linda Carr/Environmental Chemist
NAME/POSITION

Linda Carr
SIGNATURE — DATE 6/20/2013

Senior Reviewer:

Donna Morgans/ Senior Risk Assessor
NAME/POSITION

Donna L Morgans
SIGNATURE — DATE 6/28/13

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Responsible Manager: **Alaa Aly/Modeling and Risk Integration**
NAME/POSITION

SIGNATURE

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DATE

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Terms

ATSDR	Agency for Toxic Substances and Disease Registry
CalEPA	California Environmental Protection Agency
CDI	chronic daily intake
COPC	contaminant of potential concern
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
DA_{event}	dermally absorbed dose per event
DOE	U.S. Department of Energy
ECF	Environmental Calculation File
ELCR	excess lifetime cancer risk
EPA	Environmental Protection Agency
EPC	exposure point concentration
GIABS	gastrointestinal absorption factor
HEAST	Health Effects Assessment Summary Tables
HEIS	Hanford Environmental Information System
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
IUR	inhalation unit risk
MCL	maximum contaminant level
MRL	minimal risk levels
NCEA	National Center for Environmental Assessment
NJDEP	New Jersey Department of Environmental Protection
OEHHA	Office of Environmental Health Hazard Assessment (CalEPA)
ORIA	Office of Radiation and Indoor Air
ORNL	Oak Ridge National Laboratory
OSWER	Office of Solid Waste and Emergency Response (EPA)
OU	Operable Unit
pCi	picocurie

PPRTV	Provisional Peer Reviewed Toxicity Values
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RfC	reference concentration
RfD	reference dose
RME	reasonable maximum exposure
STSC	superfund health risk technical support center
SF	slope factor
VF	volatilization factor

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1 Purpose

The purpose of this environmental calculation is to document the calculation of potential human health risks and hazards associated with exposure to contaminants in the 100-FR-3 Groundwater Operable Unit (OU) for two Native American exposure scenarios. Exposure is evaluated assuming a hypothetical failure of current administrative controls, such that tribal use of 100-FR-3 OU groundwater becomes possible. Cancer risks and non-cancer hazards are calculated based on current groundwater conditions for both radioactive and nonradioactive analytes. For purposes of this calculation, any analyte detected at least once in groundwater at the 100-FR-3 OU is included in the exposure and risk calculations. Potential health risks are calculated for ingestion, inhalation, and dermal exposure routes from use of groundwater as a domestic drinking water source and from use as a source of steam in a sweat lodge. The results of all exposure routes are summed to calculate total excess lifetime cancer risk (ELCR) and hazard index (HI). This risk assessment supports DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*.

2 Background

Several local and regional tribes have ancestral ties to the Hanford Reach of the Columbia River, and the U.S. Department of Energy (DOE) has requested that each tribe provide an exposure scenario that reflects their traditional activities. The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and the Yakama Nation have provided scenarios.

For purposes of this environmental calculation, adult and child members of the CTUIR and the Yakama Nation are assumed to use groundwater from the 100-FR-3 OU as a drinking water source (i.e., domestic supply) and to make steam in a sweat lodge (adult tribal members only) as a part of their traditional lifeways.

Use of groundwater to irrigate crops and water livestock is not evaluated, because those exposure pathways, although potentially complete, are considered insignificant and secondary to the drinking water and sweat lodge exposure pathways. Such food-chain and leaching exposure pathways are evaluated separately in the PRG calculations provided in DOE/RL-2010-98, because the RESRAD model (ANL 2009, *RESRAD*, Version 6.5) used to estimate exposures considers these pathways. Contact with contaminated drill cuttings is not addressed; only the drinking water and sweat lodge exposure pathways are relevant to the Native American exposure scenarios.

2.1 Carcinogenic Effects

The potential for carcinogenic effects is evaluated by estimating the incremental increase in the probability of developing cancer over a lifetime (excess lifetime cancer risk [ELCR]), above the background probability of developing cancer (that is, if no exposure to site contaminants occurs). Cancer slope factors developed by the EPA are considered to be plausible upper bound estimates of the cancer potencies of contaminants. Using these cancer slope factors in calculating risks results in plausible, upper-bound estimates of risk; there is reasonable confidence that the actual cancer risks will not exceed the estimated risks and may actually be lower (EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final)*. The following equations are used to estimate cancer risk for non-radionuclides and radionuclides:

For nonradionuclides:

$$Risk = CDI \times SF \tag{1}$$

where:

Risk	=	Excess lifetime cancer risk (unitless probability)
CDI	=	Chronic daily intake, averaged over a lifetime (mg/kg-day)
SF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$

For radionuclides:

$$Risk = Intake \times SF \tag{2}$$

where:

Risk	=	Excess lifetime cancer risk (unitless probability)
Intake	=	Activity (pCi)
SF	=	Cancer slope factor $(pCi)^{-1}$

For cases with high ELCR values, defined as an ELCR greater than 0.01, the following "one-hit" cancer risk equation from EPA RAGS Part A guidance (EPA/540/1-89/002) is used.

$$Risk = 1 - \exp(-CDI \times SF) \tag{3}$$

where:

Risk	=	Excess lifetime cancer risk (unitless probability)
CDI	=	Chronic daily intake, averaged over a lifetime (mg/kg-day) or (pCi)
SF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$ or $(pCi)^{-1}$

Although synergistic or antagonistic interactions might occur between cancer-causing contaminants and other contaminants, information is generally lacking in the toxicological literature to predict quantitatively the effects of these potential interactions. Therefore, in this assessment, cancer risks are treated as independent, and additive within an exposure route. This is consistent with the EPA guidelines on chemical mixtures presented in EPA/630/P-03/001F, *Guidelines for Carcinogen Risk Assessment.*

EPA considers external radiation to be a significant exposure route for radionuclides only in soil (EPA/540/1-89/002); external radiation from radionuclides in water is considered insignificant, due to the radiation shielding effect of the water. Therefore, EPA does not publish radionuclide cancer slope factors to quantify cancer risk from external or dermal exposure to radionuclides in water. Because this evaluation assesses risks associated with radionuclides only in water, radionuclide cancer risk is calculated only for the ingestion and inhalation exposure routes.

2.2 Noncarcinogenic Effects

For noncancer effects, the likelihood that a receptor will develop an adverse effect is estimated by comparing the predicted level of exposure for a particular contaminant with the highest level of exposure that is considered protective (that is, its reference dose [RfD]). The ratio of the chronic daily intake (CDI) divided by the RfD is termed the hazard quotient (HQ):

$$HQ = \frac{\text{Chemical Intake (mg/kg - day)}}{\text{RfD (mg/kg - day)}} \quad (4)$$

When the HQ for a contaminant exceeds 1 (that is, exposure exceeds the RfD), there is a concern for potential noncancer health effects. To assess the potential for noncancer effects posed by exposure to multiple contaminants, a hazard index (HI) approach is used, in accordance with EPA guidance (EPA/540/1-89/002). This approach assumes that the noncancer hazards associated with exposure to multiple contaminants are simply additive; synergistic or antagonistic interactions between contaminants, which are largely unknown, are not accounted for.

2.3 Exposure Routes

Potentially complete exposure routes for adult and child tribal members associated with using groundwater as a domestic drinking water supply are:

- Ingestion of drinking water,
- Inhalation of volatiles when showering and using drinking water for other domestic purposes, and
- Dermal exposure from showering and using drinking water for other domestic purposes (e.g., washing dishes).

Potentially complete exposure routes for adult tribal members associated with using groundwater in a sweat lodge are:

- Inhalation of volatiles, semi-volatiles, and aerosolized non-volatiles, while spending time in a sweat lodge, and
- Dermal contact with vapors and condensed liquid, while spending time in a sweat lodge.

2.4 References

For the drinking water exposure pathway, contaminant intake is quantified using standard EPA equations and procedures, as specified in the following references:

- EPA/540/1-89/002, *Risk Assessment Guidance for Superfund: Volume 1—Human Health Evaluation Manual, Part A, Interim Final*;
- EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim*;
- EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final*;
- EPA-540-R-070-002, *Risk Assessment Guidance for Superfund: Volume 1:Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), Final.*
- ORNL, 2013, The Risk Assessment Information System (RAIS) (http://rais.ornl.gov/)
    - RAIS Risk Exposure Models for Chemicals User's Guide (http://rais.ornl.gov/tools/rais_chemical_risk_guide.html)

- RAIS Risk Exposure Models for Radionuclides User's Guide (http://rais.ornl.gov/tools/rais_rad_risk_guide.html)

For the sweat lodge exposure pathway, contaminant intake is quantified based on standard EPA methods, coupled with the sweat lodge steam model provided in:

- Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

The CTUIR and Yakama Nation provided many of the exposure factors necessary to quantify contaminant intake in the following references. Those values are used preferentially, rather than EPA residential default values. Where tribal-specific factors are not provided, EPA defaults are used (EPA/540/R-92/003).

- Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways;*
- Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments; and*
- Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment.*

3 Methodology

This section provides the equations (and their bases) used to calculate the cancer risks and noncancer hazards associated with exposure to the 100-FR-3 OU analytes via the exposure routes associated with the drinking water and sweat lodge exposure pathways.

3.1 Drinking Water Exposure Pathway

Definitions of the variables and input values for the drinking water exposure pathway equations are provided in Table 3-1 for the CTUIR exposure scenario, and in Table 3-2 for the Yakama Nation exposure scenario.

3.1.1 Intake and Risk Equations for Drinking Water Ingestion

The bases for the equations used to calculate intake, risk, and hazard associated with the drinking water ingestion exposure route are summarized in Table 3-3. Equations are provided in the following subsections.

3.1.1.1 Drinking Water Ingestion—Carcinogenic Effects

For ingestion of carcinogens, the chronic daily intake (CDI) is calculated using the following equations:

$$CDI = \frac{C_w \times IRW_{adj} \times EF}{AT \times CF1} \tag{5}$$

where:

$$IRW_{adj} = \frac{ED_c \times IRW_c}{BW_c} + \frac{(ED_a - ED_c) \times IRW_a}{BW_a} \tag{6}$$

Cancer risk is calculated using the following equation:

$$RISK = CDI \times CSF_o \tag{7}$$

3.1.1.2 Drinking Water Ingestion—Noncarcinogenic Effects

For ingestion of noncarcinogens, the CDI is calculated using the following equation:

$$CDI = \frac{C_w \times IRW_a \times EF \times ED_a}{BW_a \times AT \times CF1} \tag{8}$$

Noncancer hazard is calculated using the following equation:

$$HQ = \frac{CDI}{RfD_o} \tag{9}$$

3.1.1.3 Drinking Water Ingestion—Radionuclides

For ingestion of radionuclides, the CDI is calculated using the following equations:

$$CDI = C_w \times IRW\_RAD_{adj} \times EF \tag{10}$$

where:

$$IRW\_RAD_{adj} = (ED_c \times IRW_c) + ([ED_a - ED_c] \times IRW_a) \tag{11}$$

Radiological cancer risk is calculated using the following equation:

$$RISK = CDI \times SF_o \tag{12}$$

3.1.2 Intake and Risk Equations for Drinking Water Inhalation (Volatiles Only)

The bases for the equations used to calculate intake, risk, and hazard associated with inhalation of volatiles in drinking water are summarized in Table 3-4. Equations are provided in the following subsections.

3.1.2.1 Drinking Water Inhalation of Volatiles—Carcinogenic Effects

For inhalation of carcinogens, the CDI is calculated using the following equation:

$$CDI = \frac{C_w \times ED_a \times EF \times ET_a \times CF2 \times VF \times \left(1000 \frac{\mu g}{mg}\right)}{AT \times CF1} \tag{13}$$

Cancer risk is calculated using the following equation:

$$RISK = CDI \times IUR \tag{14}$$

3.1.2.2 Drinking Water Inhalation of Volatiles—Noncarcinogenic Effects

For inhalation of noncarcinogens, the CDI is calculated using the following equation:

$$CDI = \frac{C_W \times ED_a \times EF \times ET_a \times CF2 \times VF}{AT \times CF1} \tag{15}$$

Noncancer hazard is calculated using the following equation:

$$HQ = \frac{CDI}{RfC} \tag{16}$$

3.1.2.3 Drinking Water Inhalation of Volatiles—Radionuclides

For inhalation of radionuclides, the CDI is calculated using the following equations:

$$CDI = C_w \times INH\_RAD_{adj} \times VF \times EF \times ET_{adj} \times CF2 \tag{17}$$

where:

$$INH\_RAD_{adj} = (ED_c \times INH_c) + ([ED_a - ED_c] \times INH_a) \tag{18}$$

and:

$$ET_{adj} = \frac{(ET_c \times ED_c) + ((ED_a - ED_c) \times ET_a)}{ED_a} \tag{19}$$

Radiological cancer risk is calculated using the following equation:

$$RISK = CDI \times SF_i \tag{20}$$

3.1.3 Intake and Risk Equations for Drinking Water Dermal Absorption

The bases for the equations used to calculate intake, risk, and hazard associated with the drinking water dermal absorption exposure route are provided in Table 3-5. The equations are presented in the following subsections.

3.1.3.1 Drinking Water Dermal Absorption— Carcinogenic Effects

For dermal exposure to carcinogens, the CDI is calculated using the following equations:

$$CDI = \frac{DA_{event} \times SA_{adj} \times EF}{AT \times CF1} \tag{21}$$

where:

$$SA_{adj} = \frac{ED_c \times SA_c \times EV_c}{BW_c} + \frac{(ED_a - ED_c) \times SA_a \times EV_a}{BW_a} \tag{22}$$

Cancer risk is calculated using the following equation:

$$RISK = CDI \times \frac{CSF_O}{GIABS} \tag{23}$$

3.1.3.2 Drinking Water Dermal Absorption— Noncarcinogenic Effects

For dermal exposure to noncarcinogens, the CDI is calculated using the following equation:

$$CDI = \frac{DA_{event} \times SA_a \times EF \times ED_a \times EV}{BW_a \times AT \times CF1} \tag{24}$$

Noncancer hazard is calculated using the following equation:

$$HQ = \frac{CDI}{RfD_o \times GIABS} \tag{25}$$

3.1.3.3 Drinking Water Dermal Absorption— Event Time (Carcinogenic Effects and Noncarcinogenic Effects)

The event time used in the risk calculations is health effect-dependent. For noncarcinogens, the event time is not age-adjusted ($ET = ET_a$). For carcinogens, an age-adjusted event time is calculated using the following equation:

$$ET_{adj} = \frac{(ET_c \times ED_c) + ((ED_a - ED_c) \times ET_a)}{ED_a} \tag{26}$$

3.1.3.4 Drinking Water Dermal Absorption— Dermally Absorbed Dose (Carcinogenic Effects and Noncarcinogenic Effects)

For organics, the following equations are used to calculate the dermally absorbed dose per event (DA_{event}), using the adult exposure time for noncarcinogenic effects and the age-adjusted exposure time (as calculated above) for carcinogenic effects and:

If ET ≤ t*, then the following nonsteady-state equation is used:

$$DA_{event} = 2 \times FA \times K_p \times C_w \times CF3 \times \sqrt{\frac{6 \times \tau \times ET}{\pi}} \tag{27}$$

If ET > t*, then the following pseudosteady-state equation is used:

$$DA_{event} = FA \times K_p \times C_w \times CF3 \times \left[\frac{ET}{1+B} + 2 \times \tau \times \left(\frac{1+3B+3B^2}{(1+B)^2} \right) \right] \tag{28}$$

Where $ET = ET_a$ *or* ET_{adj}, for noncarcinogenic and carcinogenic effects, respectively.

For inorganics, the following steady-state equation is used to estimate DA_{event}:

$$DA_{event} = K_p \times C_w \times ET \times CF3 \quad (29)$$

Where $ET = ET_a$ *or* ET_{adj}, for noncarcinogenic and carcinogenic effects, respectively.

3.1.3.5 Drinking Water Dermal Absorption— Radionuclides

Dermal exposure to radionuclides in drinking water is not evaluated. As noted, EPA does not publish radionuclide cancer slope factors to calculate cancer risk from external or dermal exposure to radioactive contaminants in water, due to the shielding effects of water.

3.2 Sweat Lodge Exposure Pathway

Exposure factors used to quantify contaminant intake from sweat lodge exposure are provided in Table 3-6 for the CTUIR exposure scenario and in Table 3-7 for the Yakama Nation exposure scenario. Sweat lodge exposure is evaluated (for adults only) based on an exposure frequency of 365 days/yr over a 68-year exposure duration (first 2 years of life excluded)[1] for the CTUIR scenario and a 70-year exposure duration for the Yakama Nation scenario. (Although the provided exposure scenarios indicate that childhood sweats occur, exposure assumptions are made for adults only.)

[1] Child exposure assumptions were not provided for the purpose of evaluating exposure through sweat lodge use; therefore, an adult exposure duration was assumed to be 68 years for the CTUIR scenario and 70 years for the Yakama Nation scenario.

3.2.1 Intake and Risk Equations for Sweat Lodge Inhalation of Volatiles and Semi-Volatiles

The bases for the equations used to calculate intake, risk, and hazard associated with the inhalation of volatiles and semi-volatiles during sweat lodge use are summarized in Table 3-8. Equations are provided in the following subsections.

3.2.1.1 Sweat Lodge Inhalation of Volatiles and Semi-Volatiles—Intake (Carcinogenic Effects and Noncarcinogenic Effects)

Inhalation intake of volatiles and semi-volatiles in sweat lodge vapor is calculated with the following equation (Harris and Harper 2004, Appendix 4, Equation 7):

$$I_{inh} = \frac{C_{dw} \times \left(\frac{V_{w,total}}{2}\right) \times \left(\frac{1}{\frac{2}{3} \cdot \pi \cdot r^3}\right) \times IR \times ET \times EF \times ED}{BW \times AT \times CF1} \tag{30}$$

3.2.1.2 Sweat Lodge Inhalation of Volatiles and Semi-Volatiles—Carcinogenic Effects

For carcinogens, the cancer risk is calculated using the following equation:

$$RISK = CSF_i \times I_{inh} \tag{31}$$

3.2.1.3 Sweat Lodge Inhalation of Volatiles and Semi-Volatiles—Noncarcinogenic Effects

For noncarcinogens, the noncancer hazard is calculated using the following equation:

$$HQ = \frac{1}{RfD_i} \times I_{inh} \tag{32}$$

3.2.1.4 Sweat Lodge Inhalation of Volatiles and Semi-Volatiles—Radionuclides

Inhalation intake of volatile and semi-volatile radionuclides in sweat lodge vapor is calculated with the following equation (modified for pCi/L groundwater concentration units and inhalation slope factors from Harris and Harper, 2004, Appendix 4, Equation 7):

$$I_{inh} = C_{dw} \times \left(\frac{V_{w,total}}{2}\right) \times \left(\frac{1}{\frac{2}{3} \cdot \pi \cdot r^3}\right) \times IR \times ET \times EF \times ED \tag{33}$$

Radiological cancer risk is calculated using the following equation:

$$RISK_{rad} = SF_i \times I_{inh} \tag{34}$$

3.2.2 Intake and Risk Equations for Sweat Lodge Inhalation of Nonvolatiles

The bases for the equations used to calculate intake, risk, and hazard associated with the inhalation of nonvolatiles exposure route during sweat lodge use are summarized in Table 3-9. Equations are provided in the following subsections.

3.2.2.1 Sweat Lodge Inhalation of Nonvolatiles—Intake (Carcinogenic Effects and Noncarcinogenic Effects)

Inhalation intake of aerosolized nonvolatile contaminants in a sweat lodge is calculated using the following equation (Harris and Harper 2004, Appendix 4, Equation 15):

$$I_{inh} = \left(\frac{IR \cdot ET \cdot EF \cdot ED}{BW \cdot AT \cdot CF1}\right) \times C_{dw} \times \left(\frac{MW_w}{R \cdot T \cdot \rho_w}\right) \times EXP\left(18.3036 - \frac{3816.44}{T - 46.13}\right) \quad (35)$$

3.2.2.2 Sweat Lodge Inhalation of Nonvolatiles—Carcinogenic Effects

For carcinogens, the cancer risk is calculated using the following equation:

$$RISK = CSF_i \times I_{inh} \quad (36)$$

3.2.2.3 Sweat Lodge Inhalation of Nonvolatiles—Noncarcinogenic Effects

For noncarcinogens, the noncancer hazard is calculated using the following equation:

$$HQ = \frac{1}{RfD_i} \times I_{inh} \quad (37)$$

3.2.2.4 Sweat Lodge Inhalation of Nonvolatiles—Radionuclides

Inhalation intake of aerosolized nonvolatile radionuclides in a sweat lodge is calculated with the following equation (modified for pCi/L groundwater concentration units and inhalation slope factors from Harris and Harper, 2004, Appendix 4, Equation 15):

$$I_{inh} = (IR \times ET \times EF \times ED) \times C_{dw} \times \left(\frac{MW_w}{R \cdot T \cdot \rho_w}\right) \times EXP\left(18.3036 - \frac{3816.44}{T - 46.13}\right) \quad (38)$$

Radiological cancer risk is calculated using the following equation:

$$RISK_{rad} = SF_i \times I_{inh} \quad (39)$$

3.2.3 Intake and Risk Equations for Sweat Lodge Dermal Exposure to Volatiles and Semi-Volatiles

The bases for the equations used to calculate intake, risk, and hazard associated with the dermal exposure route for volatiles and semi-volatiles during sweat lodge use are summarized in Table 3-10. Equations are provided in the following subsections.

3.2.3.1 Sweat Lodge Dermal Exposure to Volatiles and Semi-Volatiles—Intake (Carcinogenic Effects and Noncarcinogenic Effects)

For volatile and semi-volatile compounds, the Harris and Harper model assumes 100% volatilization within the sweat lodge. Vapor exposure is the primary exposure pathway, and exposure from condensed water is considered incomplete. Therefore, $I_{d,total}$ is equal to $I_{d,v}$.

Exposure from dermal contact with volatile and semi-volatile contaminants in sweat lodge vapor is calculated with the following equation (Harris and Harper 2004, Appendix 4, Equation 18):

$$I_{d,total} = I_{d,v} = \frac{C_{dw} \times \left(\frac{V_{w,total}}{2}\right) \times \left(\frac{1}{\frac{2}{3} \cdot \pi \cdot r^3}\right) \times SA \times Kp \times ET \times EF \times ED \times CF2}{BW \times AT \times CF1} \quad (40)$$

3.2.3.2 Sweat Lodge Dermal Exposure to Volatiles and Semi-Volatiles—Carcinogenic Effects

For carcinogens, the cancer risk is calculated using the following equation:

$$RISK = \frac{CSF_o}{GIABS} \times I_{d,total} \quad (41)$$

3.2.3.3 Sweat Lodge Dermal Exposure to Volatiles and Semi-Volatiles—Noncarcinogenic Effects

For noncarcinogens, the noncancer hazard is calculated using the following equation:

$$HQ = \frac{1}{RfD_o \times GIABS} \times I_{d,total} \quad (42)$$

3.2.3.4 Sweat Lodge Dermal Exposure to Volatiles and Semi-Volatiles—Radionuclides

Dermal exposure to volatile and semi-volatile radionuclides in a sweat lodge is not evaluated because radionuclide cancer slope factors are not published for cancer risk from external or dermal exposure to radioactive contaminants in water.

3.2.4 Intake and Risk Equations for Sweat Lodge Dermal Exposure to Nonvolatiles

The bases for the equations used to calculate intake, risk, and hazard associated with the dermal exposure route for nonvolatiles during sweat lodge use are summarized in Table 3-11. Equations are provided in the following subsections.

3.2.4.1 Sweat Lodge Dermal Exposure to Nonvolatiles in Condensed Liquid—Intake (Carcinogenic Effects and Noncarcinogenic Effects)

In the Harris and Harper model, total dermal intake of nonvolatile contaminants is calculated as the sum of intakes from dermal exposure to vapors and to aqueous condensate. For condensed liquid, the model assumes nonvolatile contaminant concentrations in the condensed water are equal to that of the water added to the heated rocks. Intake from dermal contact with nonvolatile compounds in sweat lodge condensed liquid is calculated with the following equation (Harris and Harper 2004, Appendix 4, Equation 19):

$$I_{d,l} = \frac{C_{dw} \times SA \times K_p \times ET \times EF \times ED \times CF3}{BW \times AT \times CF1} \quad (43)$$

3.2.4.2 Sweat Lodge Dermal Exposure to Nonvolatiles in Vapor—Intake (Carcinogenic Effects and Noncarcinogenic Effects)

Intake from dermal contact with nonvolatile compounds in sweat lodge vapor is calculated with the following equation (Harris and Harper 2004, Appendix 4, Equation 20):

$$I_{d,v} = \left(\frac{SA \times K_p \times ET \times EF \times ED \times CF3}{BW \times AT \times CF1} \right) \times C_{dw} \times \left(\frac{MW_w}{R \times T \times \rho_w} \right) \times \ldots$$
$$\ldots EXP \left(18.3036 - \frac{3816.44}{T - 46.13} \right) \quad (44)$$

3.2.4.3 Sweat Lodge Dermal Exposure to Nonvolatiles in Vapor—Total Intake (Carcinogenic Effects and Noncarcinogenic Effects)

The total dermal exposure for nonvolatile compounds in a sweat lodge is calculated using the following equation (Harris and Harper 2004, Appendix 4, Equation 21):

$$I_{d,total} = I_{d,v} + I_{d,l} \quad (45)$$

3.2.4.4 Sweat Lodge Dermal Exposure to Nonvolatiles—Carcinogenic Effects

For carcinogens, the cancer risk is calculated using the following equation:

$$RISK = \frac{CSF_O}{GIABS} \times I_{d,total} \quad (46)$$

3.2.4.5 Sweat Lodge Dermal Exposure to Nonvolatiles—Noncarcinogenic Effects

For noncarcinogens, the noncancer hazard is calculated using the following equation:

$$HQ = \frac{1}{RfD_O \times GIABS} \times I_{d,total} \quad (47)$$

3.2.4.6 Sweat Lodge Dermal Exposure to Nonvolatiles—Radionuclides

Dermal exposure to radionuclides in a sweat lodge is not evaluated because radionuclide cancer slope factors are not published for calculating cancer risk from external or dermal exposure to radioactive contaminants in water.

3.3 Cumulative Risk—Cancer

For estimating the cancer risks from exposure to multiple carcinogens from a single exposure route, the following equation is used. The basis for the equation is provided in EPA/540/1-89/002.

$$Risk_T = \sum_1^N Risk_i \quad (48)$$

where:

$Risk_T$	=	Total cancer risk from route of exposure
$Risk_i$	=	Cancer risk for the ith chemical
N	=	Number of chemicals

3.4 Hazard Index—Noncancer

The HI is calculated with the following equation. The basis for the equation is provided in EPA/540/1-89/002.

$$HI = \sum_{1}^{N} CDI_i \Big/ RfD_i \tag{49}$$

where:

HI	=	hazard index
CDI_i	=	chronic daily intake of the ith chemical (mg/kg-day)
RfD_i	=	reference dose of the ith chemical (mg/kg-day)
N	=	number of chemicals

4 Assumptions and Inputs

Assumptions and inputs associated with the exposure scenarios and human health toxicity values, along with the groundwater analytes and associated exposure point concentrations (EPCs), used in the CTUIR and Yakama Nation human health risk calculations, are described below.

4.1 Exposure Inputs and Assumptions

- Exposure inputs used to quantify intake from the drinking water exposure pathway are provided in Tables 3-1 and 3-2 for the CTUIR and Yakama Nation exposure scenarios, respectively. Exposure inputs used to quantify intake from the sweat lodge exposure pathway are provided in Tables 3-6 and 3-7 for the CTUIR and Yakama Nation exposure scenarios, respectively.
- Exposure routes evaluated for the drinking water exposure pathway for the CTUIR and Yakama Nation exposure scenarios are ingestion, inhalation, and dermal absorption. (Dermal exposure is evaluated for nonradionuclides only.)
- Exposure routes evaluated for the sweat lodge exposure pathway for the CTUIR and Yakama Nation exposure scenarios are inhalation and dermal absorption. (Dermal exposure is evaluated for nonradionuclides only.)
- For domestic use of groundwater as a drinking water supply, EPA considers the inhalation pathway potentially complete only for volatile contaminants, because there is no mechanism for release of nonvolatile chemicals into the air in significant concentrations (EPA/540/R-92/003). For the drinking water exposure pathway, inhalation intake is quantified for volatile contaminants as defined by EPA, 2012, *Regional Screening Levels for Chemical Contaminants at Superfund Sites*.
- Exposure times for dermal exposure to drinking water are assumed to be 35 minutes for an adult and 1 hour for a child based on the EPA recommended values for showering/bathing under a reasonable maximum exposure (RME) residential scenario (EPA/540/R/99/005). Exposure times for inhalation of volatiles in drinking water are assumed to be the same as for the dermal exposure route.
- The Yakama Nation exposure scenario (Ridolfi, 2007) did not provide intake equations for exposures related to sweat lodge use; therefore, equations provided by Harris and Harper were used.
- The CTUIR exposure scenario (Harris and Harper 2004) provides a full set of factors needed to quantify contaminant intake from sweat lodge use. The Yakama Nation exposure scenario (Ridolfi 2007) provides a partial set of the needed factors. The tribal-specific factors are used preferentially in

the sweat lodge calculations. Where tribal-specific factors are not provided, values consistent with those used in the River Corridor Baseline Risk Assessment (RCBRA) (DOE/RL-2007-21, *River Corridor Baseline Risk Assessment, Volume II: Human Health Risk Assessment*) are generally used. Summaries of the key exposure assumptions used to quantify contaminant intake from sweat lodge use for the CTUIR and Yakama Nation scenarios are provided in Tables 4-1 and 4-2, respectively.

- Harris and Harper, 2004, Appendix 4, indicates that the water concentration (C_{dw}) is "dissolved surface water concentration of the COPC (mg/L); calculated according to EPA 1998a, Appendix B." However, for this assessment, the EPCs were used for C_{dw}; the EPCs are calculated based on total concentrations (not dissolved concentrations) in groundwater. (Total concentrations are typically higher than dissolved concentrations.)
- For the sweat lodge scenario, an exposure time of 1 hour/event is used for the CTUIR, based on Harris and Harper, 2004. For the Yakama Nation, an exposure time of 7 hours/event is used based on Ridolfi, 2007. Seven hours/day is the recommended sweat lodge exposure time, based on the maximum value reported in a tribal survey (Ridolfi, 2007).
- The sweat lodge scenario assumes 4 liters of groundwater are poured over hot rocks to make steam in a hemispherical sweat lodge with a radius of 1 m (Harris and Harper, 2004). The internal temperature of the sweat lodge is assumed to be maintained at a constant 150 degrees Fahrenheit (Harris and Harper, 2004). This scenario creates a unique environment where volatile, semi-volatile, and nonvolatile analytes could potentially be present in the air and available for inhalation and dermal exposure. Harris and Harper, 2004 describes a method for calculating a vaporization factor for the sweat lodge scenario. The vaporization factor is applied to the groundwater concentration to estimate analyte concentrations in sweat lodge steam. Ridolfi (2007) does not specify a method for estimating analyte concentrations in sweat lodge steam; therefore, the Harris and Harper steam model is used for both the CTUIR and Yakama Nation intake calculations.
- Harris and Harper recommend different methods for calculating vaporization factors for volatile and semi-volatile analytes, versus nonvolatile analytes. For volatile and semi-volatile analytes, the model assumes 100 percent volatilization throughout the sweat; hence, dermal exposure to volatiles and nonvolatiles in condensed water is considered an incomplete pathway. Therefore, volatile and semi-volatile analytes (including tritium) are evaluated for intake via inhalation and dermal absorption only from the vapor phase.
- For nonvolatile analytes, the model assumes that the analytes become airborne as an aerosol and that, once airborne, the analytes can deposit onto the skin surface as aqueous condensate. Nonvolatile analyte intake is assumed to occur via inhalation from the vapor phase and dermal absorption from both the vapor and liquid phases. The Harris and Harper model assumes the concentration of nonvolatiles in condensed water is equal to the concentration in the water used to create the steam.

4.2 Groundwater Analytes and Exposure Point Concentrations

The analytes assessed in this environmental calculation were identified from the 100-FR-3 OU analytical data set in the Hanford Environmental Information System (HEIS) database. The data set was first processed as described in ECF-100FR3-11-0023, *Identification of Contaminants of Potential Concern for Groundwater Risk Assessment at the 100-FR-3 Groundwater Operable Unit*, to exclude analytes classed as essential nutrients (minerals), analytes without known toxicity information, and nondetected analytes.

For this assessment, any analyte in the (processed) 100-FR-3 OU data set with at least one reported detection and available toxicity values was assessed in the Native American risk calculations.

The EPCs used for the Native American risk calculations are the analyte-specific 90th percentile groundwater concentration values calculated from the (processed) 100-FR-3 OU analytical data set, as described in ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*. The identified analytes and their associated 90th percentile values are presented in Table 4-3.

4.3 Toxicity Values

The toxicity criteria used for the Native American human health risk calculations are provided in Table 4-4. The sources for these criteria are discussed below.

4.3.1 Toxicity Values for Nonradionuclides

For nonradionuclides, the analyte-specific toxicity values shown in Table 4-4 are determined using the recommended reference hierarchy as described in Cook, 2003, "*Human Health Toxicity Values in Superfund Risk Assessments*." The hierarchy is summarized below.

- Tier 1 – The EPA Integrated Risk Information System (IRIS)
- Tier 2 – The EPA Provisional Peer Reviewed Toxicity Values (PPRTVs)
- Tier 3 – Other Toxicity Values

Tier 1 – IRIS

The preferred source of toxicity data is the EPA IRIS database (http://www.epa.gov/iris/index.html). EPA toxicologists derived the values in this database. The values have undergone thorough review and validation, both within and outside EPA. If a toxicity value is available in IRIS, that value is used in preference to any other value.

Tier 2 – PPRTVs

If a toxicity value is not available in IRIS, the next source is the EPA PPRTVs. This source includes toxicity values that have been developed by the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (STSC). This database is not available to the general public, but is accessible to EPA risk assessors via the EPA intranet. These values are also published at the EPA Regional Screening Levels website (EPA, 2012).

Tier 3 – Other Toxicity Values

If neither a Tier 1 or Tier 2 value is available for an analyte, a Tier 3 value is sought. Tier 3 includes additional EPA and non-EPA sources of toxicity information, including:

- The California EPA's (CalEPA's) Toxicity Criteria Database. This database contains both cancer and non-cancer effects toxicity values that have been peer reviewed.

- The Agency for Toxic Substances and Disease Registry (ATSDR)'s Minimal Risk Levels (MRLs) for Hazard Substances. These levels are peer-reviewed estimates of permissible daily human exposure to hazardous substances that are likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure.
- Toxicity values in EPA/540-R-97-036, *Health Effects Assessment Summary Tables (HEAST)*.

When Tier 1, Tier 2, and Tier 3 toxicity values are not available for an analyte, the toxicity values from the National Center for Environmental Assessment (NCEA) are used. NCEA values can be found in the Risk Assessment Information System (RAIS, ORNL, 2013).

For this environmental calculation, one toxicity value required conversion to a different concentration basis: nitrate.

- **Nitrate**. A derived RfD for nitrate (NO_3^-) was calculated from the RfD reported in IRIS, which is given as 1.6 mg/kg-day for *nitrate as nitrogen* (NO_3^- as N). Conversion from *nitrate as nitrogen* to *nitrate* was made using the mass fraction of nitrogen in nitrate. The mass fraction of nitrogen in nitrate = mol wt N/mol wt NO_3^- = (14 g/mol)/(62 g/mol) = 0.226. The derived RfD for *nitrate* = (1.6 mg NO_3^- as N/kg-day) x (1 mg NO_3^-/0.226 mg NO_3^- as N) = 7.1 mg NO_3^-/kg-day.

For hexavalent chromium, a departure from the recommended EPA Superfund hierarchy (Cook 2003) was made for the oral cancer slope factor. The departure is summarized below.

- For hexavalent chromium, this assessment considers cancer effects only for inhalation exposures. An oral cancer slope factor has recently been published by the New Jersey Department of Environmental Protection (NJDEP). The oral cancer slope factor derived by NJDEP is 0.5 $(mg/kg\text{-}day)^{-1}$, as presented in NJDEP, 2009, *Derivation of an Ingestion-Based Soil Remediation Criterion for Cr+6 Based on the NTP Chronic Bioassay Data for Sodium Dichromate Dihydrate*. Assessing only inhalation cancer effects from hexavalent chromium has the potential to under-estimate cancer risk.

4.3.2 Toxicity Values for Radionuclides

The cancer slope factors for radionuclides in Table 4-4 were obtained from EPA, 2001, "*Health Effects Assessment Summary Tables* database" / "April 16, 2001 Update: Radionuclide Toxicity," / "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

4.3.3 Toxicity Values for Sweat Lodge Equations

EPA has recently published guidance to address chemical inhalation exposures in EPA-540-R-070-002. A methodology is provided to use the toxicity values that are currently provided in IRIS as concentrations (reference concentrations [RfC] for non-cancer effects and inhalation unit risk values [IUR] for cancer endpoints). These values now supersede the intake-based approach specified in EPA/540/1-89/002.

The method described in Harris and Harper, 2004 for inhalation of nonradionuclide analytes in sweat lodge vapor follows the former EPA/540/1-89/002 approach of quantifying intake. Therefore, in the sweat lodge exposure pathway calculations, the IUR and RfC values from the EPA toxicity tables (EPA, 2012) were converted to CSF_i and RfD_i values, following the protocol given in EPA/540/1-89/002. The following equations were used, based on an assumed breathing rate of 20 m^3/day and an assumed body weight of 70 kg.

$$CSF_i \text{ (kg-day/mg)} = IUR \text{ (m}^3\text{/µg)} \times 1/[20 \text{ (m}^3\text{/day)}] \times 70 \text{ (kg)} \times 1000 \text{ (µg/mg)} \quad (50)$$

$$RfD_i \text{ (mg/kg-day)} = RfC \text{ (mg/m}^3\text{)} \times 20 \text{ (m}^3\text{/day)} \times 1/70 \text{ (kg)} \quad (51)$$

The CSF_i and RfD_i values are used to calculate inhalation cancer risks and inhalation non-cancer hazards, respectively. For inhalation of radionuclides in sweat lodge vapor, no toxicity factor conversions are necessary. Sweat lodge radiological risk is calculated by quantifying inhalation intake (pCi) and then multiplying by the EPA inhalation slope factor (risk/pCi).

5 Software Applications

All calculations for this Environmental Calculation were performed on electronic spreadsheets using Microsoft Excel®. These spreadsheets are provided as attachments to this environmental calculation.

6 Calculation

Potential human health risks to members of the CTUIR and the Yakama Nation are calculated using the methodology, analytes, EPCs, and toxicity factors documented in Sections 3 and 4 of this environmental calculation. The calculation spreadsheets were validated by comparison with the hand calculations presented in Figure 6-1.

6.1 Drinking Water Exposure Pathway Worksheets

The drinking water exposure pathway calculations for the CTUIR exposure scenario are provided in the attachments listed in Table 6-1.

The drinking water exposure pathway calculations for the Yakama Nation exposure scenario are provided in the attachments listed in Table 6-2.

6.2 Sweat Lodge Exposure Pathway Worksheets

The sweat lodge exposure pathway calculations for the CTUIR exposure scenario are provided in the attachments listed in Table 6-3.

The sweat lodge exposure pathway calculations for the Yakama Nation exposure scenario are provided in the attachments listed in Table 6-4.

6.3 Hand Calculations

The electronic spreadsheet calculations are validated by comparison with hand calculations. The hand calculations are presented in Figure 6-1. The hand calculations were performed to validate the formulas used in the spreadsheets.

7 Results/Conclusions

Results of the CTUIR and Yakama Nation human health risk calculations are summarized and discussed in the sections below.

® Microsoft Excel is a registered product of the Microsoft Corporation.

7.1 Summary of the CTUIR Risk Assessment

This section summarizes the risk assessment results for use of groundwater as a drinking water source and use of groundwater to make steam in a sweat lodge, where the groundwater source is the 100-FR-3 OU.

7.1.1 Use of Groundwater as a Potential Drinking Water Source

Potential exposure to groundwater as a drinking water source is evaluated under this scenario. Potential routes of exposure to groundwater include ingestion, dermal contact (nonradionuclides only), and inhalation of volatiles during household activities. Table 7-1 provides a summary of the risk estimates, by exposure route. Additional detail, including analyte-specific risk contributions, is provided in the spreadsheet attachments.

The total ELCR is 8.6×10^{-4} for nonradiological analytes and 4.9×10^{-5} for radiological analytes. The nonradiological ELCR is greater than the EPA upper target risk threshold of 1×10^{-4} and the radiological ELCR is within the EPA risk range of 1×10^{-4} to 1×10^{-6}. The major contributors to the total cumulative ELCR (those analytes that contribute greater than 1 percent of total cumulative ELCR) are 1,4-dioxane (4.4×10^{-5}; 4.9 percent contribution), trichloroethene (3.3×10^{-5}; 3.6 percent contribution), strontium-90 (1.8×10^{-5}; 1.9 percent contribution), and tritium (1.4×10^{-5}; 1.6 percent contribution). Contribution to ELCR is elevated for arsenic (7.8×10^{-4}; 86 percent contribution), where measured concentrations are within natural background values.

The HI is 6.6, which is greater than the EPA target HI of 1.0. The primary contributor to the noncancer HI (those analytes that contribute greater than 1 percent of HI) is trichloroethene (HQ=1.4; 22 percent contribution). All remaining individual analytes (fluoride, hexavalent chromium, lithium, molybdenum, nitrate, strontium, and vanadium) that contribute greater than one percent of the HI also report a HQ less than 1. Contribution to the noncancer HI is elevated for arsenic (HQ = 1.7; 26 percent contribution), where measured concentrations are within natural background values.

7.1.2 Use of Groundwater as a Source of Steam for Sweat Lodge Use

Potential exposure to groundwater as a source of steam in a sweat lodge is evaluated under this scenario. Potential routes of exposure to steam generated from groundwater while spending time in a sweat lodge include 1) inhalation of vaporized volatiles and semi-volatiles and aerosolized nonvolatiles, and 2) dermal contact with vaporized volatiles and semi-volatiles, aerosolized nonvolatiles, and condensed liquid. Table 7-2 provides a summary of the risk estimates by exposure route. Additional detail including analyte-specific risk contributions is provided in the spreadsheet attachments.

The total ELCR is 1.4×10^{-2} for nonradiological analytes and 1.5×10^{-4} for radiological analytes, which are both greater than the EPA upper target risk threshold of 1×10^{-4}. The major contributor to the total cumulative ELCR (those analytes that contribute greater than 1 percent of total cumulative ELCR) is hexavalent chromium (1.4×10^{-2}; 96 percent contribution). Contribution to ELCR is elevated for arsenic (3.2×10^{-4}; 2.2 percent contribution), where measured concentrations are within natural background values.

The HI is 11, which is greater than the EPA target HI of 1.0. The primary contributors to the noncancer HI (those analytes that contribute greater than 1 percent of HI) are barium (HQ = 1.9; 17 percent contribution) and hexavalent chromium (HQ = 1.8; 17 percent contribution). All remaining individual analytes (cobalt, fluoride, manganese, nickel, and trichloroethene) that contribute greater than one percent of the HI also report a HQ less than 1. Contribution to the noncancer HI is elevated for arsenic (HQ = 5.1; 45 percent contribution), where measured concentrations are within natural background values.

7.2 Summary of the Yakama Nation Risk Assessment

This section summarizes the risk assessment results for use of groundwater as a drinking water source and use of groundwater to make steam in a sweat lodge, where the groundwater source is the 100-FR-3 OU.

7.2.1 Use of Groundwater as a Potential Drinking Water Source

Potential exposure to groundwater as a drinking water source is evaluated under this scenario. Potential routes of exposure to groundwater include ingestion, dermal contact (nonradionuclides only), and inhalation of volatiles during household activities. Table 7-3 provides a summary of the risk estimates, by exposure route. Additional detail, including analyte-specific risk contributions, is provided in the spreadsheet attachments.

The total ELCR is 9.3×10^{-4} for nonradiological analytes and 5.0×10^{-5} for radiological analytes. The nonradiological ELCR is greater than the EPA upper target risk threshold of 1×10^{-4} and the radiological ELCR is within the EPA risk range of 1×10^{-4} to 1×10^{-6}. The major contributors to the total cumulative ELCR (those analytes that contribute greater than 1 percent of total cumulative ELCR) are 1,4-dioxane, (4.8×10^{-5}; 4.9 percent contribution), trichloroethene (3.5×10^{-5}; 3.6 percent contribution), strontium-90 (1.8×10^{-5}; 1.8 percent contribution), and tritium (1.5×10^{-5}; 1.5 percent contribution). Contribution to ELCR is elevated for arsenic (8.5×10^{-4}; 86 percent contribution), where measured concentrations are within natural background values.

The HI 6.6, which is greater than the EPA target HI of 1.0. The primary contributor to the noncancer HI (those analytes that contribute greater than 1 percent of total HI) is trichloroethene (HQ=1.4; 22 percent contribution). All remaining individual analytes (fluoride, hexavalent chromium, lithium, molybdenum, nitrate, strontium, and vanadium) that contribute greater than one percent of the HI also report a HQ less than 1. Contribution to the noncancer HI is elevated for arsenic (HQ = 1.7; 26 percent contribution), where measured concentrations are within natural background values.

7.2.2 Use of Groundwater as a Source of Steam for Sweat Lodge Use

Potential exposure to groundwater as a source of steam in a sweat lodge is evaluated under this scenario. Potential routes of exposure to steam generated from groundwater while spending time in a sweat lodge include 1) inhalation of vaporized volatiles and semi-volatiles and aerosolized nonvolatiles, and 2) dermal contact with vaporized volatiles and semi-volatiles, aerosolized nonvolatiles, and condensed liquid. Table 7-4 provides a summary of the risk estimates by exposure route. For comparison purposes, Table 7-5 provides a summary of risk estimates calculated without contributions from aerosolized nonvolatile analytes. Additional detail including analyte-specific risk contributions is provided in the spreadsheet attachments.

The total ELCR *with* contributions from aerosolized nonvolatile analytes is 1.0×10^{-1} for nonradiological analytes and 1.1×10^{-3} for radiological analytes, which are both greater than the EPA upper target risk threshold of 1×10^{-4}. The major contributor to the total cumulative ELCR (those analytes that contribute greater than 1 percent of total cumulative ELCR) is hexavalent chromium (9.9×10^{-2}; 96 percent contribution). Contribution to ELCR is elevated for arsenic (2.4×10^{-3}; 2.3 percent contribution), where measured concentrations are within natural background values.

The total ELCR *without* contributions from nonvolatile analytes is 6.7×10^{-5} for nonradiological analytes and 2.8×10^{-5} for radiological analytes. The nonradiological ELCR is greater than the EPA upper target risk threshold of 1×10^{-4} and the radiological ELCR is within the EPA risk range of 1×10^{-4} to 1×10^{-6}. The major contributors to the total cumulative ELCR (those analytes that contribute greater than 1 percent of total cumulative ELCR) are tritium (2.8×10^{-5}; 29 percent contribution), 1,4-dioxane (2.1×10^{-5}; 22

percent frequency), trichloroethene (1.6×10^{-5}; 17 percent contribution), and chloroform (3.8×10^{-6}; 4.0 percent contribution). Contribution to ELCR is elevated for arsenic (2.4×10^{-5}; 25 percent contribution), where measured concentrations are within natural background values.

The HI *with* contributions from nonvolatile analytes is 82, which is greater than the EPA target HI of 1.0. The primary contributors to the noncancer HI (those analytes that contribute greater than 1 percent of total HI) are barium (HQ = 14; 17 percent contribution), hexavalent chromium (HQ = 13; 16 percent contribution), manganese (HQ = 7.5; 9.1 percent contribution), nickel (HQ = 3.5; 4.2 percent contribution), fluoride (HQ = 2.5; 3.0 percent contribution), trichloroethene (HQ = 2.0; 2.4 percent contribution), and cobalt (HQ = 1.8; 2.2 percent contribution). Contribution to the noncancer HI is elevated for arsenic (HQ = 37; 45 percent contribution), where measured concentrations are within natural background values.

The HI *without* contributions from nonvolatile analytes is 3.2, which is greater than the EPA target HI of 1.0. The primary contributor to the noncancer HI (those analytes that contribute greater than 1 percent of total HI) is trichloroethene (HQ = 2.0; 63 percent contribution). All remaining individual analytes (arsenic, bromoethane, hexavalent chromium, and lithium) that contribute greater than one percent of the HI also report a HQ less than 1.

8 References

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Figures

Figure 6-1
HAND CALCULATIONS
(12 Sheets)

100-FR-3 Tribal Risk Assessment K. Singleton 3/14/11 ⓪

• Drinking Water - Ingestion Nonradionuclides

CTUR

Carcinogen

$$CDI = \frac{C_w \cdot IRW_{adj} \cdot EF}{AT \cdot CF_1}$$

$$IRW_{adj} = \frac{ED_c \cdot IRW_c}{BW_c} + \frac{[ED_a - ED_c] \cdot IRW_a}{BW_a}$$

$$Risk = CDI \cdot CSF_o$$

→ Arsenic

$$IRW_{adj} = \frac{6yr * 1\frac{L}{d}}{15kg} + \frac{(70yr - 6yr) * 4\frac{L}{d}}{70kg}$$

$$= 4.057 \frac{L\text{-}yr}{kg\text{-}d}$$

$$CDI = \frac{8.955E\text{-}3 \frac{mg}{L} * 4.057 \frac{L\text{-}yr}{kg\text{-}d} * 365 \frac{d}{yr}}{70yr * 365 \frac{d}{yr}}$$

$$= 5.19E\text{-}4 \frac{mg}{kg\text{-}d}$$

$$Risk = 5.19E\text{-}4 \frac{mg}{kg\text{-}d} * 1.5$$

$$= 7.79E\text{-}4$$

Noncarcinogen

$$CDI = \frac{C_w \cdot IRW_a \cdot EF \cdot ED_a}{BW_a \cdot AT \cdot CF_1}$$

$$HQ = \frac{CDI}{RfD_o}$$

→ Arsenic

$$CDI = \frac{8.955E\text{-}3 \frac{mg}{L} * 4\frac{L}{d} * 365\frac{d}{yr} * 70yr}{70kg * 70yr * 365 \frac{d}{yr}}$$

$$= 5.12E\text{-}4 \frac{mg}{kg\text{-}d}$$

$$HQ = 5.12E\text{-}4 \frac{mg}{kg\text{-}d} / 3.00E\text{-}4 \frac{mg}{kg\text{-}d}$$

$$= 1.71$$

100-FR-3 Tribal Risk Assessment K. Singleton 3/16/11 ②

• Drinking Water Ingestion - Radionuclides

$$CDI = C_w \cdot IRW\_RADadj \cdot EF$$

$$IRW\_RADadj = (ED_c \cdot IRW_c) + ([ED_a - ED_c] \cdot IRW_a)$$

$$Risk = CDI \cdot SF_o$$

→ Tritium

$$IRW\_RADadj = \left(6yr \times 1 \tfrac{L}{d}\right) + \left([70yr - 6yr] \times 4 \tfrac{L}{d}\right)$$

$$= 262 \ \tfrac{L\text{-}yr}{d}$$

$$CDI = 2700 \ \tfrac{pCi}{L} \times 262 \ \tfrac{L\text{-}yr}{d} \times 365 \ \tfrac{d}{yr}$$

$$= 2.58E{+}8 \ pCi$$

$$Risk = 2.58E{+}8 \ pCi \times 5.07E{-}14 \ \tfrac{risk}{pCi}$$

$$= 1.31E{-}5$$

• Drinking Water Inhalation of Volatiles - Nonradionuclide

Carcinogen

$$CDI = \frac{C_w \cdot ED_a \cdot EF \cdot ET_a \cdot CF_a \cdot VF \cdot \left(1000 \ \tfrac{ug}{mg}\right)}{AT \cdot CF_1}$$

$$Risk = CDI \cdot IUR$$

→ Chloroform

$$CDI = \frac{4556^{4} \ \tfrac{mg}{L} \times 70yr \times 365 \ \tfrac{d}{yr} \times 0.58 \ \tfrac{hr}{d} \times \tfrac{1 \ d}{24 hr} \times 0.5 \ \tfrac{L}{m^3} \times 1000 \ \tfrac{ug}{mg}}{70yr \times 365 \ \tfrac{d}{yr}}$$

$$= 5.50E{-}3 \ \tfrac{ug}{m^3}$$

Noncarcinogen

$$CDI = \frac{C_w \cdot ED_a \cdot EF \cdot ET_a \cdot CF_a \cdot VF}{AT \cdot CF_1}$$

$$HQ = \frac{CDI}{RFC}$$

100-FR-3 Tribal Risk Assessment K Singleton 3/16/11 (3)

→ Chloroform

$$CDI = \frac{4.55E^{-4}\ \frac{mg}{L} * 70yr * 365\ \frac{d}{yr} * 0.58\ \frac{hr}{d} * \frac{1d}{24hr} * 0.5\ \frac{L}{m^3}}{70\ yr * 365\ \frac{d}{yr}}$$

$$= 5.80E^{-6}\ \frac{mg}{m^3}$$

$$HQ = 5.50E^{-6}\ \frac{mg}{m^3} / 9.80E^{-2}\ \frac{mg}{m^3}$$

$$= 5.61\ E^{-5}$$

• Drinking Water Inhalation of Volatiles - Radronuclides

$$CDI = C_w \cdot INH\_RADadj \cdot VF \cdot EF \cdot ETadj \cdot CF_2$$

$$INH\_RADadj = (ED_c \cdot INH_c) + ([ED_a - ED_c] \cdot INH_a)$$

$$ETadj = \frac{(ET_c \cdot ED_c) + ([ED_a - ED_c] \cdot ET_a)}{ED_a}$$

$$Risk = CDI \cdot SF_i$$

→ Tritium

$$ETadj = \frac{(1\ \frac{hr}{d} * 6yr) + ([70yr - 6yr] * 25\ \frac{m^3}{d})}{70yr}$$

$$= 0.616\ \frac{hr}{d}$$

$$INH\_RADadj = (6yr * 15\ \frac{m^3}{d}) + ([70yr - 6yr] * 25\ \frac{m^3}{d})$$

$$= 1690\ \frac{m^3 \cdot yr}{d}$$

$$CDI = 2700\ \frac{pCi}{L} * 1690\ \frac{m^3 \cdot yr}{d} * 0.5\ \frac{L}{m^3} * 365\ \frac{d}{yr} * 0.616\ \frac{hr}{d} * \frac{1d}{24hr}$$

$$= 2.14E^{+7}\ pCi$$

$$Risk = 2.14E^{+7}\ pCi * 5.62E^{-14}$$

$$= 1.20E^{-6}$$

100-FR-3 Tribal Risk Assessment K Singleton 5/16/11 (9)

• Drinking Water Dermal Absorption

Carcinogen

$$CDI = \frac{DA_{event} \cdot SA_{adj} \cdot EF}{AT \cdot CF_1}$$

$$SA_{adj} = \frac{ED_c \cdot SA_c \cdot EV_c}{BW_c} + \frac{(ED_a - ED_c) \cdot SA_a \cdot EV_a}{BW_a}$$

$$Risk = CDI \cdot \frac{CSF_o}{GIABS}$$

If $ET \le t^*$,

$$DA_{event} = 2 \cdot FA \cdot K_p \cdot C_w \cdot CF_3 \cdot \sqrt{\frac{6 \cdot \tau \cdot ET}{\pi}}$$

If $ET > t^*$

$$DA_{event} = FA \cdot K_p \cdot C_w \cdot CF_3 \cdot \left[\frac{ET}{1+B}\right] + 2 \cdot \tau \left[\frac{1 + 3B + 3B^2}{(1+B)^2}\right]$$

Inorganic

$$DA_{event} = K_p \cdot C_w \cdot ET \cdot CF_3$$

$$ET_{adj} = \frac{1 \frac{hr}{d} \times 6yr + [70yr - 6yr] \times 2.56 \frac{hr}{d}}{70yr}$$

$$= 0.616 \frac{hr}{d}$$

$$SA_{adj} = \frac{6yr \times 6600 cm^2 \times 1 \frac{event}{d}}{15 Kg} + \frac{[70yr - 6yr] \times 18000 cm^2 \times 1 \frac{event}{d}}{70 Kg}$$

$$= 19097 \frac{cm^2 \cdot yr \cdot event}{Kg \cdot d}$$

100-FR-3 Tribal Risk Assessment K. Singleton 3/16/11 (5)

→ Chloroform

$$DAevent = 2 \times 1 \times 6.80E^{-3}\ \frac{cm}{hr} \times 4.55E^{-4}\ \frac{mg}{L} \times 0.001\ \frac{L}{cm^3} \times \frac{\sqrt{6 \times 0.5\ \frac{hr}{event} \times 0.646\ \frac{hr}{event}}}{3.14}$$

$$= 6.19E^{-9} \times \sqrt{0.588}\ \frac{mg}{cm^2\text{-}event}$$

$$= 4.75E^{-9}\ \frac{mg}{cm^2\text{-}event}$$

$$CDI = \frac{4.75E^{-9}\ \frac{mg}{cm^2\text{-}event} \times 19097\ \frac{cm^2\text{-}yr\text{-}event}{kg\text{-}d} \times 365\ \frac{d}{yr}}{70\ yr \times 365\ \frac{d}{yr}}$$

$$= 1.29E^{-6}\ \frac{mg}{kg\text{-}d}$$

$$Risk = 1.29E^{-6}\ \frac{mg}{kg\text{-}d} \times \frac{3.10E^{-2}\ \frac{kg\text{-}d}{mg}}{1}$$

$$= 4.01E^{-8}$$

→ Arsenic

$$DAevent = 0.001\ \frac{cm}{hr} \times 8.955E^{-3}\ \frac{mg}{L} \times 0.646\ \frac{hr}{event} \times 0.001\ \frac{L}{cm^3}$$

$$= 5.52E^{-9}\ \frac{mg}{cm^2\text{-}event}$$

$$CDI = \frac{5.52E^{-9}\ \frac{mg}{cm^2\text{-}event} \times 19097\ \frac{cm^2\text{-}yr\text{-}event}{kg\text{-}d} \times 365\ \frac{d}{yr}}{70\ yr \times 365\ \frac{d}{yr}}$$

$$= 1.50E^{-6}\ \frac{mg}{kg\text{-}d}$$

$$Risk = 1.50E^{-6}\ \frac{mg}{kg\text{-}d} \times \left(1.5\ \frac{kg\text{-}d}{mg} / 1\right)$$

$$= 2.26E^{-6}$$

Noncarcinogen

$$CDI = \frac{DAevent \cdot SA_a \cdot EF \cdot ED_a \cdot EV}{BW_a \cdot AT \cdot CF_1}$$

$$HQ = \frac{CDI}{RFD_o \cdot GIABS}$$

100-FR-3 Tribal Risk Assessment K.Singleton 3/16/11 ⑥

If $ET \le t^*$

$$DAevent = 2 \cdot FA \cdot Kp \cdot Cw \cdot CF3 \cdot \sqrt{\frac{6 \cdot \tau \cdot ET}{\pi}}$$

If $ET > t^*$

$$DAevent = FA \cdot Kp \cdot Cw \cdot CF3 \left(\left[\frac{ET}{1+B} \right] + 2 \cdot \tau \cdot \left[\frac{1 + 3B + 3B^2}{(1+B)^2} \right] \right)$$

Inorganic

$$DAevent = Kp \cdot Cw \cdot ET \cdot CF3$$

→ Chloroform

$$DAevent = 2 * 1 * 6.80E{-3}\,\frac{cm}{hr} * 4.55E{-4}\,\frac{mg}{L} * 0.001\,\frac{L}{cm^3} * \sqrt{\frac{6 * 0.5\,\frac{hr}{event} * 0.58\,\frac{hr}{event}}{3.14}}$$

$$= 6.19E{-9} \cdot \sqrt{0.564}\ \frac{mg}{cm^2\text{-event}}$$

$$= 4.61E{-9}\ \frac{mg}{cm^2\text{-event}}$$

$$CDI = \frac{4.61E{-9}\ \frac{mg}{cm^2\text{-event}} * 18000\,cm^2 * 365\,\frac{d}{yr} * 70\,yr * 1\,\frac{event}{d}}{70\,kg * 70\,yr * 365\,\frac{d}{yr}}$$

$$= 1.18E{-6}\ \frac{mg}{kg\text{-}d}$$

$$HQ = \frac{1.18E{-6}\ \frac{mg}{kg\text{-}d}}{6.61\ \frac{mg}{kg\text{-}d} * 1} = 1.18E{-6}$$

→ Arsenic

$$DAevent = 0.001\,\frac{cm}{hr} * 8.955E{-3}\,\frac{mg}{L} * 0.58\,\frac{hr}{event} * 0.001\,\frac{L}{cm^3}$$

$$= 5.19E{-9}\ \frac{mg}{cm^2\text{-event}}$$

$$CDI = \frac{5.19E{-9}\ \frac{mg}{cm^2\text{-event}} * 18000\,cm^2 * 365\,\frac{d}{yr} * 70\,yr * 1\,\frac{event}{d}}{70\,kg * 70\,yr * 365\,\frac{d}{yr}}$$

$$= 1.34E{-6}\ \frac{mg}{kg\text{-}d}$$

$$HQ = 1.34E{-6}\ \frac{mg}{kg\text{-}d}$$

100-FR-3 Tribal Risk Assessment K. Singleton 3/16/11 ⑦

CTUIR

• Sweathlodge - Inhalation of Volatiles & Semi Volatiles - Nonradionuclides

$$I_{inh} = \frac{C_{air} \cdot \left[\frac{\text{Vapor}}{\text{d}}\right] \cdot \left[\frac{1}{243\,\pi r^3}\right] \cdot IR \cdot ET \cdot EF \cdot ED}{BW \cdot AT \cdot CF_1}$$

Carcinogen

$$Risk = CSF_i \cdot I_{inh}$$

→ Chloroform

$$I_{inh} = \frac{9.55E{-4}\ \frac{mg}{L} * \left[\frac{gal}{d}\right] * \left[\frac{1}{243\,\pi (1m)^3}\right] * 25\ \frac{m^3}{d} * \frac{1\,d}{24\,hrs} * 365\ \frac{event}{yr} * 68\,yr}{70\,kg * 70\,yr * 365\ \frac{d}{yr}}$$

$$= 6.28E^{-6}\ \frac{mg}{kg\text{-}d}$$

$$Risk = 6.28E^{-6}\ \frac{mg}{kg\text{-}d} * 8.05E^{-2}\ \frac{kg\text{-}d}{mg}$$

$$= 5.06\,E^{-7}$$

Noncarcinogen

$$HQ = \frac{1}{RfD_i} \cdot I_{inh}$$

→ Chloroform

$$I_{inh} = \frac{9.55E{-4}\ \frac{mg}{L} * \left[\frac{gal}{d}\right] * \left[\frac{1}{243\,\pi (1m)^3}\right] * 25\ \frac{m^3}{d} * \frac{1\,d}{24\,hrs} * 365\ \frac{event}{yr} * 68\,yr}{70\,kg * 68\,yr * 365\ \frac{d}{yr}}$$

$$= 6.47\,E^{-6}\ \frac{mg}{kg\text{-}d}$$

$$HQ = \frac{1}{2.8E^{-2}\ \frac{mg}{kg\text{-}d}} * 6.47E^{-6}\ \frac{mg}{kg\text{-}d}$$

$$= 2.31\,E^{-4}$$

100-FR-3 Tribal Risk Assessment K.Singleton 3/16/11 (3)

• Sweetlodge - Inhalation of Volatile - Radionuclide

$I_{inh} = C_{air} \cdot \left[\frac{V_{inhaled}}{2}\right] \cdot \left[\frac{1}{315\,m^3/s}\right] \cdot IR \cdot ET \cdot EF \cdot ED$

$Risk = SF_i \cdot I_{inh}$

→ Tritium

$I_{inh} = 2200\,\frac{pCi}{L} * \left[\frac{1\,gal}{3\,L}\right] * \left[\frac{1}{4.53\,m^3/(1\,gal)^3}\right] * 25\,\frac{m^3}{d} * \frac{1\,d}{24\,event} * 365\,\frac{event}{yr} * 68\,yr$

$= 6.67E^{+7}\,pCi$

$Risk = 6.67E^{+7}\,pCi * 5.62E^{-14}\,\frac{risk}{pCi}$

$= 3.75E^{-6}$ ✓

• Sweetlodge - Inhalation of Nonvolatile

$I_{inh} = \left[\frac{IR \cdot ET \cdot EF \cdot ED}{BW \cdot AT \cdot CF_1}\right] \cdot C_{air} \cdot \left[\frac{MW_w}{R \cdot T \cdot R_c}\right] \cdot Exp\left[18.3036 - \frac{3816.44}{T - 46.13}\right]$

Carcinogen

$Risk = CSF_i \cdot I_{inh}$

→ Arsenic

$I_{inh} = \left[\frac{25\,\frac{m^3}{d} * \frac{1\,d}{24\,event} * 365\,\frac{event}{yr} * 68\,yr}{70\,kg * 70\,yr * 365\,\frac{d}{yr}}\right] * 8.955E^{-3}\,\frac{mg}{L} * \left[\frac{15\,\frac{g}{gmol}}{0.06237\,\frac{mol\,kg^{-3}}{g\,cm^{-3}} * 338.7\,K * 1000\,\frac{g}{L}}\right] *$

$\ldots e^{\left[18.3036 - \frac{3816.44}{338.7\,K - 46.13\,mol\,kg}\right]}$

$= (1.496E^{-2} * 8.955E^{-3} * 8.52E^{-4} * 192.3)\,\frac{mg}{kg\text{-}d}$

$= 2.12E^{-5}\,\frac{mg}{kg\text{-}d}$

$Risk = 2.12E^{-5}\,\frac{mg}{kg\text{-}d} * 15.1\,\frac{kg\text{-}d}{mg}$

$= 3.20E^{-4}$ ✓ rounding

100-FR-3 Tribal Risk Assessment K.Singleton 3/16/11 (4)

Noncarcinogen

$$HQ = \frac{1}{RfD_i} \cdot I_{inh}$$

→ Arsenic

$$I_{inh} = \left[\frac{35\frac{m^3}{d} * \frac{1\,d}{24\,hrs} * 365\frac{days}{yr} * 68\,yr}{70\,kg * 68\,yr * 365\frac{d}{yr}}\right] * 8.955E^{-3}\frac{mg}{L} * \left[\frac{19\frac{g}{gmol}}{0.08\,\frac{atm\,L\,m^3}{gmol\,K} * 338.7K * 1000\frac{g}{L}}\right]$$

$$19.3036 - \frac{3816.44}{338.7K - 46.13\,mmHg}$$

... e

$$= (1.488E^{-2} * 8.955E^{-3} * 8.52E^{-4} * 1923)\frac{mg}{kg\text{-}d}$$

$$= 2.18E^{-5}\frac{mg}{kg\text{-}d}$$

$$HQ = \frac{1}{4.29E^{-6}\frac{mg}{kg\text{-}d}} * 2.18E^{-5}\frac{mg}{kg\text{-}d}$$

$$= 5.09$$

• Sweatlodge - Inhalation of Nonvolatile - Radionuclide

$$I_{inh} = (R \cdot ET \cdot EF \cdot ED) \cdot C_{dw} \cdot \left[\frac{MW_w}{R \cdot T \cdot P_w}\right] \cdot Exp\ 19.3036 - \frac{3816.44}{T - 46.13}$$

$$Risk = I_{inh} \cdot SF_i$$

→ Technetium-99

$$I_{inh} = \left(35\frac{m^3}{d} * \frac{1\,d}{24\,hrs} * 365\frac{days}{yr} * 68\,yr\right) * 6.105\frac{pCi}{L} * \left[\frac{19\frac{g}{gmol}}{0.08\,\frac{atm\,L\,m^3}{gmol\,K} * 338.7K * 1000\frac{g}{L}}\right] *$$

$$\left[19.3036 - \frac{3816.44}{338.7K - 46.13\,mmHg}\right]$$

... e

$$= (2.59E^{4} * 6.105 * 8.52E^{-4} * 1923)\,pCi$$

$$= 2.59E^{4}\,pCi$$

$$Risk = 2.59E^{4}\,pCi * 1.41E^{-11}\frac{risk}{pCi}$$

$$= 3.65E^{-7}$$

100-FR-3 Tribal Risk Assessment K.Singleton 3/16/11 (12)

• Sweathodge - Dermal Absorption - Volatiles

$$I_{d,total} = I_{d,v} = \frac{C_{air} \cdot \left[\frac{V_{air,total}}{A}\right] \cdot \left[\frac{1}{4/3\pi r^3}\right] \cdot SA \cdot kp \cdot ET \cdot EF \cdot ED \cdot CF_2}{BW \cdot AT \cdot CF_1}$$

Carcinogen

$$Risk = \frac{CSF_o}{GIABS} \cdot I_{d,total}$$

→ Chloroform

$$I_{d,total} = \frac{9.55E^{-4}\frac{mg}{L} \times \left[\frac{4L}{A}\right] \times \left[\frac{1}{4/3\pi(1m)^3}\right] \times 18m^2 \times 6.8E^{-3}\frac{cm}{hr} \times 1\frac{hr}{60min} \times 365\frac{min}{yr} \times 68yr \times 0.01\frac{m}{cm}}{70kg \times 70yr \times 365\frac{d}{yr}}$$

$$= 7.35E^{-10}\ \frac{mg}{kg\text{-}d}$$

$$Risk = \frac{3.10E^{-2}\frac{kg\text{-}d}{mg}}{1} \times 7.35E^{-10}\ \frac{mg}{kg\text{-}d}$$

$$= 2.29E^{-11}$$

Noncarcinogen

$$HQ = \frac{1}{RfD_o \cdot GIABS} \times I_{d,total}$$

→ Chloroform

$$I_{d,total} = \frac{9.55E^{-4}\frac{mg}{L} \times \left[\frac{4L}{3}\right] \times \left[\frac{1}{4/3\pi(1m)^3}\right] \times 18m^2 \times 6.8E^{-3}\frac{cm}{hr} \times 1\frac{hr}{60min} \times 365\frac{min}{yr} \times 68yr \times 0.01\frac{m}{cm}}{70kg \times 68yr \times 365\frac{d}{yr}}$$

$$= 7.60E^{-10}\ \frac{mg}{kg\text{-}d}$$

$$HQ = \frac{7.60E^{-10}\frac{mg}{kg\text{-}d}}{0.01\frac{mg}{kg\text{-}d} \times 1}$$

$$= 7.60E^{-8}$$

100-FR-3 Tribal Risk Assessment K.Singleton 3/16/11 (Hr)

• Sweatlodge Dermal Absorption - Nonvolatile Condensed Liquid

$$I_{d,i} = \frac{C_{aw} \cdot SA \cdot K_p \cdot ET \cdot EF \cdot ED \cdot CF_3}{BW \cdot AT \cdot CF_1}$$

Carcinogen

$$Risk = \frac{CSF_o}{GIABS} \cdot I_{d,i}$$

→ Arsenic

$$I_{d,i} = \frac{8.955E-3 \frac{mg}{L} * 1.8 m^2 * 0.001 \frac{cm}{hr} * 1 \frac{hr}{event} * 365 \frac{event}{yr} * 68 yr * 10 \frac{L}{m^2\text{-}event}}{70 kg * 70 yr * 365 \frac{d}{yr}}$$

$$= 2.24E-3 \frac{mg}{kg\text{-}d}$$

$$Risk = \frac{1.50 \frac{kg\text{-}d}{mg}}{1} * 2.24E-3 \frac{mg}{kg\text{-}d}$$

$$= 3.36E-6$$

Noncarcinogen

$$HQ = \frac{1}{RfD_o \cdot GIABS} \cdot I_{d,i}$$

→ Arsenic

$$I_{d,i} = \frac{8.955E-3 \frac{mg}{L} * 1.8 m^2 * 0.001 \frac{cm}{hr} * 1 \frac{hr}{event} * 365 \frac{event}{yr} * 68 yr * 10 \frac{L}{m^2\text{-}event}}{70 kg * 68 yr * 365 \frac{d}{yr}}$$

$$= 2.30E-6 \frac{mg}{kg\text{-}d}$$

$$HQ = \frac{1}{3.00E-4 \frac{mg}{kg\text{-}d} * 1} * 2.30E-6 \frac{mg}{kg\text{-}d}$$

$$= 7.68E-3$$

100-FR-3 Tribal Risk Assessment KSingleton 3/16/11 (2)

• Sweatlodge Dermal Absorption - Nonvolatile in Vapor

$$I_{dv} = \left[\frac{SA \cdot K_p \cdot ET \cdot EF \cdot ED \cdot CF_3}{BW \cdot AT \cdot CF_1}\right] \cdot C_{air} \cdot \left[\frac{MW}{R \cdot T \cdot P_a}\right] \cdot Exp\left[18.3036 - \frac{3816.44}{T - 46.13}\right]$$

Carcinogen

$$Risk = \frac{CSF_o}{GIABS} * I_{dv}$$

→ Arsenic

$$I_{dv} = \left[\frac{18m^2 * 0.001 \frac{cm}{hr} * 1 \frac{hr}{event} * 365 \frac{event}{yr} * 68yr * 10 \frac{L}{m^2 \cdot cm}}{70kg * 70yr * 365 \frac{d}{yr}}\right] * 8.955E^{-3} \frac{mg}{L} *$$

$$\left[\frac{18 \frac{g}{gmol}}{62.37 \frac{mmHg \cdot L}{gmol \cdot K} * 338.7K * 1000 \frac{g}{L}}\right] * Exp\left[18.3036 - \frac{3816.44}{338.7K - 46.13}\right]$$

$$= (2.50E^{-4} * 8.955E^{-3} * 8.52E^{-7} * 192.3) \frac{mg}{kg \cdot d}$$

$$= 3.67E^{-10} \frac{mg}{kg \cdot d}$$

$$Risk = \frac{1.50 \frac{kg \cdot d}{mg}}{1} * 3.67E^{-10} \frac{mg}{kg \cdot d}$$

$$= 5.50 \; E^{-10}$$

Non Carcinogen

$$HQ = \frac{1}{RfD_o \cdot GIABS} \cdot I_{dv}$$

→ Arsenic

$$I_{dv} = \left[\frac{18m^2 * 0.001 \frac{cm}{hr} * 1 \frac{hr}{event} * 365 \frac{event}{yr} * 68yr * 10 \frac{L}{m^2 \cdot cm}}{70kg * 68yr * 365 \frac{d}{yr}}\right] * 8.955E^{-3} \frac{mg}{L} *$$

$$\left[\frac{18 \frac{g}{gmol}}{62.37 \frac{mmHg \cdot L}{gmol \cdot K} * 338.7K * 1000 \frac{g}{L}}\right] * Exp\left[18.3036 - \frac{3816.44}{338.7K - 46.13}\right]$$

$$= (2.57E^{-4} * 8.955E^{-3} * 8.52E^{-7} * 192.3) \frac{mg}{kg \cdot d}$$

$$= 3.77E^{-10} \frac{mg}{kg \cdot d}$$

$$HQ = \frac{1}{3.00E^{-4} \frac{mg}{kg \cdot d}} * 3.77E^{-10} \frac{mg}{kg \cdot d} = 1.26E^{-6}$$

Tables

Table 3-1. Summary of Exposure Assumptions for the Drinking Water Exposure Pathway for the CTUIR Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source
Averaging Time – carcinogens and noncarcinogens	AT	70	years	Harris, 2008
Partitioning Constant Derived by Bunge Model	B	Analyte-specific	unitless	See Table 4-4
Body Weight - adult	BW_a	70	kg	Harris and Harper, 2004
Body Weight - child	BW_c	15	kg	Harris and Harper, 2004
Conversion Factor	CF1	365	days/year	1 year = 365 days
Conversion Factor	CF2	1/24	days/ hour	1 day = 24 hours
Conversion Factor	CF3	0.001	L/cm^3	1 L = 1,000 cm^3
Cancer Slope Factor - oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	See Table 4-4
Chronic Daily Intake – carcinogenic ingestion	CDI	Calculated value	mg/kg-day	Equation 5
Chronic Daily Intake – noncarcinogenic ingestion	CDI	Calculated value	mg/kg-day	Equation 8
Chronic Daily Intake – radiological ingestion	CDI	Calculated value	pCi	Equation 10
Chronic Daily Intake – carcinogen inhalation	CDI	Calculated value	$\mu g/m^3$	Equation 13
Chronic Daily Intake – noncarcinogenic inhalation	CDI	Calculated value	mg/m^3	Equation 15
Chronic Daily Intake – radiological inhalation	CDI	Calculated value	pCi	Equation 17
Chronic Daily Intake – carcinogenic dermal	CDI	Calculated value	mg/kg-day	Equation 21
Chronic Daily Intake – noncarcinogenic dermal	CDI	Calculated value	mg/kg-day	Equation 24
Contaminant concentration in groundwater	C_w	Analyte-specific	mg/L or pCi/L	ECF-100FR3-11-0024
Absorbed dose per event	DA_{event}	Calculated value	mg/cm^2-event	Equation 27, 28,and 29
Exposure Duration - adult	ED_a	70	Years	Harris and Harper, 2004
Exposure Duration - child	ED_c	6	Years	Harris, 2008

Table 3-1. Summary of Exposure Assumptions for the Drinking Water Exposure Pathway for the CTUIR Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source
Exposure Frequency	EF	365	days/year	Harris and Harper, 2004
Exposure Time - adult	ET_a	0.58	hours/day or hours/event	EPA/540/R/99/005
Exposure Time - child	ET_c	1	hours/day or hours/event	EPA/540/R/99/005
Age-Adjusted Exposure Time	ET_{adj}	0.616	hours/day	Equation 19
			hours/event	Equation 26
Event Frequency - adult	EV_a	1	event/day	EPA/540/R/99/005
Event Frequency - child	EV_c	1	event/day	EPA/540/R/99/005
Fraction of absorbed water	FA	Analyte-specific	unitless	See Table 4-4
Gastrointestinal Absorption Factor	GIABS	Analyte-specific	unitless	See Table 4-4
Inhalation Rate - adult	INH_a	25	m^3/day	Harris, 2008
Inhalation Rate - child	INH_c	15	m^3/day	Harris, 2008
Age-Adjusted Inhalation Rate - radiological	INH_RAD_{adj}	1,690	m^3-year/day	Equation 18
Water Ingestion Rate - adult	IRW_a	4	L/day	Harris, 2008
Water Ingestion Rate - child	IRW_c	1	L/day	Harris and Harper, 2004
Age-adjusted Water Ingestion Rate – nonradiological	IRW_{adj}	4.057	L-year/kg-day	Equation 6
Age-adjusted Water Ingestion Rate – radiological	IRW_RAD_{adj}	262	L-year/day	Equation 11
Inhalation Unit Risk	IUR	Analyte-specific	$(\mu g/m^3)^{-1}$	See Table 4-4
Dermal permeability coefficient	K_p	Analyte-specific	cm/hour	See Table 4-4
The constant pi	π	3.14159	unitless	–
Reference Concentration	RfC	Analyte-specific	mg/m^3	See Table 4-4

Table 3-1. Summary of Exposure Assumptions for the Drinking Water Exposure Pathway for the CTUIR Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source
Reference Dose - oral	RfD_o	Analyte-specific	mg/kg-day	See Table 4-4
Age-adjusted skin surface area	SA_{adj}	19,097	cm^2-year/kg-day	Equation 22
Skin Surface Area - adult	SA_a	18,000	cm^2	EPA/540/R/99/005
Skin Surface Area - child	SA_c	6,600	cm^2	EPA/540/R/99/005
Slope Factor - inhalation	SF_i	Analyte-specific	Risk/pCi	See Table 4-4
Slope Factor - oral	SF_o	Analyte-specific	Risk/pCi	See Table 4-4
Time to reach steady state conditions	t^*	Analyte-specific	Hours	See Table 4-4
Lag time	τ	Analyte-specific	hours/event	See Table 4-4
Volatilization Factor	VF	0.5	L/m^3	EPA/540/R-92/003

Notes:

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit.*

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim.*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment).*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments.*

Table 3-2. Summary of Exposure Assumptions Used for the Drinking Water Exposure Pathway for the Yakama Nation Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source
Averaging Time – carcinogens and noncarcinogens	AT	70	Year	Ridolfi, 2007
Partitioning constant Derived by Bunge Model	B	Analyte-specific	unitless	See Table 4-4
Body Weight - adult	BW_a	70	Kg	Ridolfi, 2007
Body Weight - child	BW_c	16	Kg	Ridolfi, 2007
Conversion Factor	CF1	365	days/year	1 year = 365 days
Conversion Factor	CF2	1/24	days/hour	1 day = 24 hours
Conversion Factor	CF3	0.001	L/cm^3	1 L = 1,000 cm^3
Cancer Slope Factor - oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	See Table 4-4
Chronic Daily Intake – carcinogenic ingestion	CDI	Calculated value	mg/kg-day	Equation 5
Chronic Daily Intake – noncarcinogenic ingestion	CDI	Calculated value	mg/kg-day	Equation 8
Chronic Daily Intake – radiological ingestion	CDI	Calculated value	pCi	Equation 10
Chronic Daily Intake – carcinogenic inhalation	CDI	Calculated value	$\mu g/m^3$	Equation 13
Chronic Daily Intake – noncarcinogenic inhalation	CDI	Calculated value	mg/m^3	Equation 15
Chronic Daily Intake – radiological inhalation	CDI	Calculated value	pCi	Equation 17
Chronic Daily Intake – carcinogenic dermal	CDI	Calculated value	mg/kg-day	Equation 21
Chronic Daily Intake – noncarcinogenic dermal	CDI	Calculated value	mg/kg-day	Equation 24
Contaminant concentration in groundwater	C_w	Analyte-specific	mg/L or pCi/L	ECF-100FR3-11-0024
Absorbed Dose per Event	DA_{event}	Calculated value	mg/cm^2-event	Equations 27, 28, and 29
Exposure Duration - adult	ED_a	70	Year	Ridolfi, 2007
Exposure Duration - child	ED_c	6	Year	Ridolfi, 2007
Exposure Frequency	EF	365	days/year	Ridolfi, 2007

Table 3-2. Summary of Exposure Assumptions Used for the Drinking Water Exposure Pathway for the Yakama Nation Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source
Exposure Time - adult	ET_a	0.58	hours/day or hours/event	EPA/540/R/99/005
Exposure Time - child	ET_c	1	hours/day or hours/event	EPA/540/R/99/005
Age-Adjusted Exposure Time	ET_{adj}	0.616	hours/day	Equation 19
			hours/event	Equation 26
Event Frequency - adult	EV_a	1	event/day	EPA/540/R/99/005
Event Frequency - child	EV_c	1	event/day	EPA/540/R/99/005
Fraction of absorbed water	FA	Analyte-specific	unitless	See Table 4-4
Gastrointestinal Absorption Factor	GIABS	Analyte-specific	unitless	See Table 4-4
Age-Adjusted Inhalation Rate - radiological	INH_RAD_{adj}	1,760	m^3-year/day	Equation 18
Inhalation Rate - adult	INH_a	26	m^3/day	Ridolfi, 2007
Inhalation Rate - child	INH_c	16	m^3/day	Ridolfi, 2007
Water Ingestion Rate - adult	IRW_a	4	L/day	Ridolfi, 2007
Water Ingestion Rate - child	IRW_c	2	L/day	Ridolfi, 2007
Age-adjusted Water Ingestion Rate – nonradiological	IRW_{adj}	4.407	L-year/kg-day	Equation 6
Age-adjusted Water Ingestion Rate – radiological	IRW_RAD_{adj}	262	L-year/day	Equation 11
Inhalation Unit Risk	IUR	Analyte-specific	$(\mu g/m^3)^{-1}$	See Table 4-4
Dermal permeability coefficient	K_p	Analyte-specific	cm/hour	See Table 4-4
The constant pi	π	3.14159	unitless	–
Reference Concentration	RfC	Analyte-specific	mg/m^3	See Table 4-4
Reference Dose - oral	RfD_o	Analyte-specific	mg/kg-day	See Table 4-4

Table 3-2. Summary of Exposure Assumptions Used for the Drinking Water Exposure Pathway for the Yakama Nation Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source
Age-adjusted skin surface area	SA_{adj}	18,932	cm^2-year/kg-day	Equation 22
Skin Surface Area - adult	SA_a	18,000	cm^2	EPA/540/R/99/005
Skin Surface Area - child	SA_c	6,600	cm^2	EPA/540/R/99/005
Slope Factor - inhalation	SF_i	Analyte-specific	Risk/pCi	See Table 4-4
Slope Factor - oral	SF_o	Analyte-specific	Risk/pCi	See Table 4-4
Time to reach steady state conditions	t^*	Analyte-specific	Hours	See Table 4-4
Lag time	τ	Analyte-specific	hours/event	See Table 4-4
Volatilization Factor	VF	0.5	L/m^3	EPA/540/R-92/003

Notes:

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit.*

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim.*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment).*

Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment.*

Table 3-3. Calculated Values and Reference Bases Used for the Drinking Water Ingestion Exposure Route

Effect	Symbol for Calculated Value	Reference
Carcinogenic	CDI IRW_{adj}	RAIS Risk Exposure Models for Chemicals User's Guide (ORNL, 2013)
	Risk	EPA/540/R-92/003
Noncarcinogenic	CDI	RAIS Risk Exposure Models for Chemicals User's Guide (ORNL, 2013)
	HQ	EPA/540/R-92/003
Radionuclide	CDI IRW_RAD_{adj}	RAIS Risk Exposure Models for Radionuclides User's Guide (ORNL, 2013)
	Risk	EPA/540/R-92/003

Notes:

CDI= chronic daily intake

HQ= hazard quotient

IRW_{adj} = age-adjusted water ingestion rate.

IRW_RAD_{adj} = age-adjusted water ingestion rate for radionuclides.

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim.*

ORNL, 2013, The Risk Assessment Information System (RAIS).

Table 3-4. Calculated Values and Reference Bases Used for the Drinking Water Inhalation of Volatiles Exposure Route

Effect	Symbol for Calculated Value	Reference
Carcinogenic	CDI	RAIS Risk Exposure Models for Chemicals User's Guide (ORNL, 2013)
	Risk	EPA-540-R-070-002
Noncarcinogenic	CDI	RAIS Risk Exposure Models for Chemicals User's Guide (ORNL, 2010)
	HQ	EPA-540-R-070-002
Radionuclide	CDI INH_RAD_{adj}	RAIS Risk Exposure Models for Radionuclides User's Guide (ORNL, 2013)
	ET_{adj}	EPA-540-R-070-002 and EPA/540/R/99/005
	Risk	EPA/540/R-92/003

Notes:
CDI= chronic daily intake.
ET_{adj} = age-adjusted exposure time.
HQ = hazard quotient.
INH_RAD_{adj} = age-adjusted radionuclide inhalation rate.

EPA-540-R-070-002, *Risk Assessment Guidance for Superfund: Volume 1—Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).*

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim.*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

ORNL, 2013, The Risk Assessment Information System (RAIS).

Table 3-5. Calculated Values and Reference Bases Used for the Drinking Water Dermal Exposure Route

Effect	Symbol for Calculated Value	Reference
Carcinogenic	CDI	EPA/540/R/99/005
	SA_{adj}	EPA/540/R/99/005
	ET_{adj}	EPA/540/R/99/005
	DA_{event}	EPA/540/R/99/005
	Risk	EPA/540/R/99/005
Noncarcinogenic	CDI	EPA/540/R/99/005
	DA_{event}	EPA/540/R/99/005
	HQ	EPA/540/R/99/005
Radionuclide	Not applicable	

Notes:
CDI= chronic daily intake.
DA_{event} = absorbed dose per event.
ET_{adj} = age-adjusted exposure time.
HQ = hazard quotient.
SA_{adj} = age-adjusted skin surface area.
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

Table 3-6. Summary of Exposure Assumptions Used for the Sweat Lodge Exposure Pathway for CTUIR Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source
Averaging Time – carcinogens[a]	AT	70	year	Harris and Harper, 2004
Averaging Time –noncarcinogens[a]	AT	68	year	Harris and Harper, 2004
Average Body Weight – adult	BW	70	kg	Harris and Harper, 2004
Conversion Factor	CF1	365	days/year	1 year = 365 days
Conversion Factor	CF2	0.01	m/cm	1 meter = 100 cm
Conversion Factor	CF3	10	L/m^2-cm	1 L = 0.01 m^2 x 10 cm
Groundwater Concentration[b]	C_{dw}	Analyte-specific	mg/L or pCi/L	ECF-100FR3-11-0024
Cancer Slope Factor - oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	See Table 4-4
Cancer Slope Factor - inhalation	CSF_i	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	See Table 4-4
Exposure Duration or Number of Years a Person Sweats in a Lifetime - adult	ED	68	year	Harris and Harper, 2004
Exposure Frequency or Number of Sweats per Year	EF	365	events/year	Harris and Harper, 2004
Length of Sweat Event – adult[c]	ET	1/24	days/event	Harris and Harper, 2004
Gastrointestinal Absorption Factor	GIABS	Analyte-specific	unitless	See Table 4-4
Inhalation Intake of Analytes in Sweat Lodge— volatile and semi-volatile nonradionuclides	I_{inh}	Calculated value	mg/kg-day	Equation 30
Inhalation Intake of Analytes in Sweat Lodge— volatile and semi-volatile radionuclides	I_{inh}	Calculated value	pCi	Equation 33
Inhalation Intake of Analytes in Sweat Lodge— nonvolatile nonradionuclides	I_{inh}	Calculated value	mg/kg-day	Equation 35
Inhalation Intake of Analytes in Sweat Lodge— nonvolatile radionuclides	I_{inh}	Calculated value	pCi	Equation 38
Dermal Intake of Analytes in Sweat Lodge— volatile and semi-volatile vapor	$I_{d,v} = I_{d,total}$	Calculated value	mg/kg-day	Equation 40

Table 3-6. Summary of Exposure Assumptions Used for the Sweat Lodge Exposure Pathway for CTUIR Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source
Dermal Intake of Analytes in Sweat Lodge— nonvolatile condensed liquid	$I_{d,l}$	Calculated value	mg/kg-day	Equation 43
Dermal Intake of Analytes in Sweat Lodge— nonvolatile vapor	$I_{d,v}$	Calculated value	mg/kg-day	Equation 44
Inhalation Rate - adult	IR	25	m^3/day	Harris, 2008
Inhalation Unit Risk	IUR	Analyte-specific	$(\mu g/m^3)^{-1}$	See Table 4-4
Analyte-specific Permeability Coefficient	K_p	Analyte-specific	cm/hour	See Table 4-4
Molecular Weight of Water	MW_w	18	g/gmole	Harris and Harper, 2004
Density of Liquid Water	ρ_w	1,000	g/L	Harris and Harper, 2004
The Constant pi	π	3.14159	unitless	–
Radius of Sweat Lodge	r	1	m	Harris and Harper, 2004
Ideal Gas Law Constant	R	0.06237	mmHg-m^3/mole-K	Harris and Harper, 2004
Ideal Gas Law Constant[d]	R	62.37	mmHg-L/mole-K	Harris and Harper, 2004
Reference Concentration	RfC	Analyte-specific	mg/m^3	See Table 4-4
Reference Dose - inhalation	RfD_i	Analyte-specific	mg/kg-day	See Table 4-4
Reference Dose - oral	RfD_o	Analyte-specific	mg/kg-day	See Table 4-4
Skin Surface Area - adult	SA	18,000	cm^2	Harris and Harper, 2004
Slope Factor - inhalation	SF_i	Analyte-specific	Risk/pCi	See Table 4-4
Temperature of the Sweat Lodge[e]	T	340	K	Harris and Harper, 2004
Cumulative Volume of Water Used in Sweat	$V_{w,total}$	4	Liters	Harris and Harper, 2004

Table 3-6. Summary of Exposure Assumptions Used for the Sweat Lodge Exposure Pathway for CTUIR Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source

Notes:

a. Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for carcinogens and 68 years for noncarcinogens to account for lifetime intake rather than annual intake.

b. Harris and Harper (2004, Appendix 4) indicates water concentration (C_{dw}) is "dissolved surface water concentration of the COPC (mg/L); calculated according to EPA 1998a, Appendix B." However, for this assessment analyte exposure point concentrations reflect total concentrations in groundwater.

c. For sweat lodge inhalation exposure, exposure time of 1 hour provided in Harris and Harper, 2004 was replaced with 1/24 days/event so that intake values have appropriate units (mg/kg-day or pCi) when calculated using the inhalation equations provided in Harris and Harper (2004, Equations 7 and 15).

d. For sweat lodge dermal exposure, the ideal gas law constant of 0.06237 mmHg-m^3/gmole-K provided in Harris and Harper, 2004 was replaced with 62.37 mmHg-L/gmole-K so that intake values have appropriate units (mg/kg-day) when calculated using the equations provided in Harris and Harper (2004, Equations 15 and 20).

e. Temperature of 389 K provided in Harris and Harper, 2004 was replaced with 340 K (150 °F) for consistency with stated assumption in Harris and Harper, 2004 that sweat lodge internal temperature is maintained at 150 °F.

CTUIR = Confederated Tribes of the Umatilla Indian Reservation

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit.*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments.*

Table 3-7. Summary of Exposure Assumptions Used for the Sweat Lodge Exposure Pathway for Yakama Nation Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source
Averaging Time – carcinogens[a]	AT	70	year	Harris and Harper, 2004
Averaging Time –noncarcinogens[a]	AT	70	year	Harris and Harper, 2004
Average Body Weight - adult	BW	70	kg	Harris and Harper, 2004
Conversion Factor	CF1	365	days/year	1 year = 365 days/year
Conversion Factor	CF2	0.01	m/cm	1 meter = 100 cm
Conversion Factor	CF3	10	L/m^2-cm	1 L = 0.01 m^2 x 10 cm
Groundwater Concentration[b]	C_{dw}	Analyte-specific	mg/L or pCi/L	ECF-100FR3-11-0024
Cancer Slope Factor - oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	See Table 4-4
Cancer Slope Factor - inhalation	CSF_i	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	See Table 4-4
Exposure Duration or Number of Years a Person Sweats in a Lifetime - adult	ED	70	year	Harris and Harper, 2004
Exposure Frequency or Number of Sweats per Year	EF	365	events/year	Harris and Harper, 2004
Length of Sweat Event – adult[c]	ET	7/24	days/event	Ridolfi, 2007
Gastrointestinal Absorption Factor	GIABS	Analyte-specific	unitless	See Table 4-4
Inhalation Intake of Analytes in Sweat Lodge— volatile and semi-volatile nonradionuclides	I_{inh}	Calculated value	mg/kg-day	Equation 30
Inhalation Intake of Analytes in Sweat Lodge— volatile and semi-volatile radionuclides	I_{inh}	Calculated value	pCi	Equation 33
Inhalation Intake of Analytes in Sweat Lodge— nonvolatile nonradionuclides	I_{inh}	Calculated value	mg/kg-day	Equation 35
Inhalation Intake of Analytes in Sweat Lodge— nonvolatile radionuclides	I_{inh}	Calculated value	pCi	Equation 38
Dermal Intake of Analytes in Sweat Lodge— volatile and semi-volatile vapor	$I_{d,total} = I_{d,v}$	Calculated value	mg/kg-day	Equation 40

Table 3-7. Summary of Exposure Assumptions Used for the Sweat Lodge Exposure Pathway for Yakama Nation Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source
Dermal Intake of Analytes in Sweat Lodge— nonvolatile condensed liquid	$I_{d,l}$	Calculated value	mg/kg-day	Equation 43
Dermal Intake of Analytes in Sweat Lodge— nonvolatile vapor	$I_{d,v}$	Calculated value	mg/kg-day	Equation 44
Inhalation Rate - adult	IR	26	m^3/day	Ridolfi, 2007
Inhalation Unit Risk	IUR	Analyte-specific	$(\mu g/m^3)^{-1}$	See Table 4-4
Analyte-specific Permeability Coefficient	K_p	Analyte-specific	cm/hour	See Table 4-4
Molecular Weight of Water	MW_w	18	g/gmole	Harris and Harper, 2004
Density of Liquid Water	ρ_w	1,000	g/L	Harris and Harper, 2004
The Constant pi	π	3.14159	unitless	--
Radius of Sweat Lodge	r	1	m	Harris and Harper, 2004
Ideal Gas Law Constant	R	0.06237	mmHg-m^3/mole-K	Harris and Harper, 2004
Ideal Gas Law Constant[d]	R	62.37	mmHg-L/mole-K	Harris and Harper, 2004
Reference Concentration	RfC	Analyte-specific	mg/m^3	See Table 4-4
Reference Dose - inhalation	RfD_i	Analyte-specific	mg/kg-day	See Table 4-4
Reference Dose - oral	RfD_o	Analyte-specific	mg/kg-day	See Table 4-4
Skin Surface Area - adult	SA	18,000	cm^2	Harris and Harper, 2004
Slope Factor - inhalation	SF_i	Analyte-specific	Risk/pCi	See Table 4-4
Temperature Inside the Sweat Lodge[e]	T	340	K	Harris and Harper, 2004
Cumulative Volume of Water Used in Sweat	$V_{w,total}$	4	Liters	Harris and Harper, 2004

Notes:

a. Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for both carcinogens and noncarcinogens to

Table 3-7. Summary of Exposure Assumptions Used for the Sweat Lodge Exposure Pathway for Yakama Nation Exposure Scenario in the 100-FR-3 Groundwater Operable Unit. (3 Pages)

Exposure Factor	Symbol	Value	Units	Source

account for lifetime intake rather than annual intake.

b. Harris and Harper (2004, Appendix 4) indicates water concentration (C_{dw}) is "dissolved surface water concentration of the COPC (mg/L); calculated according to EPA 1998a, Appendix B." However, for this assessment analyte exposure point concentrations reflect total concentrations in groundwater.

c. For sweat lodge inhalation exposure, exposure time of 7 hr provided in Ridolfi, 2007 was replaced with 7/24 days/event so that the intake values have appropriate units.(mg/kg-day or pCi) when calculated using the inhalation equations provided in Harris and Harper, (2004, Equations 7 and 15).

d. For sweat lodge dermal exposure, the ideal gas law constant of 0.06237 mmHg-m^3/gmole-K provided in Harris and Harper, 2004 was replaced with 62.37 mmHg-L/gmole-K so that intake values have appropriate units (mg/kg-day) when calculated using the equations provided in Harris and Harper (2004, Equations 15 and 20).

e. Temperature of 389 K provided in Harris and Harper, 2004 was replaced with 340 K (150 °F) for consistency with stated assumption in Harris and Harper, 2004 that sweat lodge internal temperature is maintained at 150 °F.

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit.*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment.*

Table 3-8. Calculated Values and Reference Bases Used for the Sweat Lodge Inhalation of Volatiles and Semi-Volatiles Exposure Route

Effect	Symbol for Calculated Value	Reference
Carcinogenic and Noncarcinogenic	I_{inh}	Harris and Harper, 2004
Carcinogenic	Risk	EPA-540-R-070-002
Noncarcinogenic	HQ	EPA-540-R-070-002
Radionuclide	I_{inh}	Harris and Harper, 2004
	Risk	EPA/540/R-92/003

Notes:

I_{inh} = Inhalation intake of analytes in sweat lodge.

HQ = hazard quotient.

EPA-540-R-070-002, *Risk Assessment Guidance for Superfund: Volume 1—Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).*

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim.*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Table 3-9. Calculated Values and Reference Bases Used for the Sweat Lodge Inhalation of Nonvolatiles Exposure Route

Effect	Symbol for Calculated Value	Reference
Carcinogenic and Noncarcinogenic	I_{inh}	Harris and Harper, 2004
Carcinogenic	Risk	EPA-540-R-070-002
Noncarcinogenic	HQ	EPA-540-R-070-002
Radionuclide	I_{inh}	Harris and Harper, 2004
	Risk	EPA/540/R-92/003

Notes:

I_{inh} = Inhalation intake of analytes in sweat lodge.

HQ = hazard quotient.

EPA-540-R-070-002, *Risk Assessment Guidance for Superfund: Volume 1—Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).*

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim.*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Table 3-10. Calculated Values and Reference Bases Used for the Sweat Lodge Dermal Exposure to Volatiles and Semi-Volatiles Exposure Route

Effect	Symbol for Calculated Value	Reference
Carcinogenic and Noncarcinogenic	$I_{d,v} = I_{d,total}$	Harris and Harper, 2004
Carcinogenic	Risk	EPA/540/R/99/005
Noncarcinogenic	HQ	EPA/540/R/99/005

Notes:

$I_{d,v}$ = Dermal intake of volatile and semi-volatile analytes in vapor in sweat lodge.

$I_{d,total}$ = Total dermal intake of volatile and semi-volatile analytes in sweat lodge.

HQ = hazard quotient.

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Part E, Supplemental Guidance for Dermal Risk Assessment): Final. (OSWER Directive 9285.7-03B-P).*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Table 3-11. Calculated Values and Reference Bases Used for the Sweat Lodge Dermal Exposure to Nonvolatiles Exposure Route

Effect	Symbol for Calculated Value	Reference
Carcinogenic and Noncarcinogenic	$I_{d,l}$	Harris and Harper, 2004
Carcinogenic and Noncarcinogenic	$I_{d,v}$	Harris and Harper, 2004
Carcinogenic and Noncarcinogenic	$I_{d,total}$	Harris and Harper, 2004
Carcinogenic	Risk	EPA/540/R/99/005
Noncarcinogenic	HQ	EPA/540/R/99/005

Notes:
$I_{d,l}$ = Dermal intake of nonvolatiles analytes in condensed liquid in sweat lodge.
$I_{d,v}$ = Dermal intake of nonvolatile analytes in vapor in sweat lodge.
$I_{d,total}$ = Total dermal intake of nonvolatile analytes in sweat lodge.
HQ = hazard quotient.

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final. (OSWER Directive 9285.7-03B-P).*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Table 4-1. Summary of Key Exposure Assumptions Used for the Sweat Lodge Exposure Pathway for the CTUIR Exposure Scenario

Exposure Factor	Symbol	Units	RI/FS Value	RCBRA Value	RCBRA Reference	CTUIR Value	CTUIR Reference
Averaging Time – carcinogens	AT	year	70[a]	75	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	1	Harris and Harper, 2004, Appendix 4
Averaging Time – noncarcinogens	AT	year	68[a]	69 (ED)	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	1	Harris and Harper, 2004, Appendix 4
Average Body Weight – adult	BW	kg	70	70	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	70	Harris and Harper, 2004, Appendix 4
Exposure Duration or Number of Years a Person Sweats in a Lifetime – adult	ED	year	68	69	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	68	Harris and Harper, 2004, Appendix 4
Exposure Frequency or Number of Sweats per Year	EF	events/year	365	365	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	365	Harris and Harper, 2004, Appendix 4
Length of Sweat Event – adult	ET	hours/event	1[b]	1	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	1	Harris and Harper, 2004, Appendix 4
Inhalation Intake of Analytes in Sweat Lodge—nonvolatile nonradionuclides	I_{inh}	mg/kg-day	Calculated value	Calculated value	RCBRA Rev. 0, Volume II, Part 1, p. 3-72 and p. 6-2	Calculated value	Harris and Harper, 2004, Appendix 4
Inhalation Intake of Analytes in Sweat Lodge—nonvolatile radionuclides	I_{inh}	pCi	Calculated value	Calculated value	RCBRA Rev. 0, Volume II, Part 1, p. 3-72 and p. 6-2	Calculated value	Harris and Harper, 2004, Appendix 4
Inhalation Rate—adult	IR	m^3/day	25	30[c]	RCBRA Rev. 0, Volume II, Part 2, p. 3-27, Table 3-19	25	Harris, 2008

Table 4-1. Summary of Key Exposure Assumptions Used for the Sweat Lodge Exposure Pathway for the CTUIR Exposure Scenario

Exposure Factor	Symbol	Units	RI/FS Value	RCBRA Value	RCBRA Reference	CTUIR Value	CTUIR Reference
Radius of Sweat Lodge	r	m	1	1	RCBRA Rev. 0, Volume II, Part 1, p. 3-71	1	Harris and Harper, 2004, Appendix 4
Skin Surface Area – adult	SA	cm^2	18,000	18,000	RCBRA Rev. 0, Volume II, Part 2, p. 3-27, Table 3-19	18,000	Harris and Harper, 2004, Appendix 4
Cumulative Volume of Water Used in Sweat	$V_{w,total}$	Liters	4	4	RCBRA Rev. 0, Volume II, Part 1, p. 3-71	4	Harris and Harper, 2004, Appendix 4

Notes:

a. Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for carcinogens and 68 years for noncarcinogens to account for lifetime intake rather than annual intake.

b. Inhalation intake calculated using 1/24 days/event for unit consistency with equations provided in Harris and Harper, 2004.

c. RCBRA references 1.25 m^3/hr, which is equivalent to 30 m^3/day (1.25 m^3/hr × 24 hrs/day).

RCBRA = River Corridor Baseline Risk Assessment (DOE/RL-2007-21)

DOE/RL-2007-21, *River Corridor Baseline Risk Assessment, Volume II: Human Health Risk Assessment.*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments.*

Table 4-2. Summary of Key Exposure Assumptions Used for the Sweat Lodge Exposure Pathway for the Yakama Nation Exposure Scenario

Exposure Factor	Symbol	Units	RI/FS Value	RCBRA Value	RCBRA Reference	Yakama Nation Value	Yakama Nation Reference
Averaging Time – carcinogens	AT	year	70[a]	70	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	Not specified	NA
Averaging Time – noncarcinogens	AT	year	70[a]	64 (ED)	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	Not specified	NA
Average Body Weight – adult	BW	kg	70	70	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	70	Ridolfi, 2007, Table 7
Exposure Duration or Number of Years a Person Sweats in a Lifetime – adult	ED	year	70	64	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	70	Ridolfi, 2007, Table 7
Exposure Frequency or Number of Sweats per Year	EF	events/year	365	365	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	365	Ridolfi, 2007, Table 7
Length of Sweat Event – adult	ET	hours/event	7[b]	7	RCBRA Rev. 0, Volume II, Part 2, p. 3-28, Table 3-19	7	Ridolfi, 2007, Table 7
Inhalation Intake of Analytes in Sweat Lodge— nonvolatile nonradionuclides	I_{inh}	mg/kg-day	Calculated both with and without	Not calculated	RCBRA Rev. 0, Volume II, Part 1, p. 3-72 and p. 6-2	Not specified	NA
Inhalation Intake of Analytes in Sweat Lodge— nonvolatile radionuclides	I_{inh}	pCi	Calculated both with and without	Not calculated	RCBRA Rev. 0, Volume II, Part 1, p. 3-72 and p. 6-2	Not specified	NA
Inhalation Rate – adult	IR	m^3/day	26	26[c]	RCBRA Rev. 0, Volume II, Part 2, p. 3-27, Table 3-19	26	Ridolfi, 2007, Table 7
Radius of Sweat Lodge	r	m	1	1	RCBRA Rev. 0, Volume II, Part 1, p. 3-71	Not specified	NA
Skin Surface Area – adult	SA	cm^2	18,000	18,000	RCBRA Rev. 0, Volume II, Part 2, p. 3-27, Table 3-19	Not specified	NA

Table 4-2. Summary of Key Exposure Assumptions Used for the Sweat Lodge Exposure Pathway for the Yakama Nation Exposure Scenario

Exposure Factor	Symbol	Units	RI/FS Value	RCBRA Value	RCBRA Reference	Yakama Nation Value	Yakama Nation Reference
Cumulative Volume of Water Used in Sweat	$V_{w,total}$	Liters	4	4	RCBRA Rev. 0, Volume II, Part 1, p. 3-71	Not specified	NA

Notes:

a. Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for both carcinogens and noncarcinogens to account for lifetime intake rather than annual intake.

b. Inhalation intake calculated using 7/24 days/event for unit consistency with equations provided in Harris and Harper, 2004.

c. RCBRA references 1.08 m^3/hr, which is equivalent to 26 m^3/day (1.08 m^3/hr × 24 hrs/day).

RCBRA = River Corridor Baseline Risk Assessment (DOE/RL-2007-21)

DOE/RL-2007-21, *River Corridor Baseline Risk Assessment, Volume II: Human Health Risk Assessment.*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment.*

Table 4-3. Analytes and Exposure Point Concentrations (90th Percentile Groundwater Concentrations) Used for the Native American Risk Assessment at the 100-FR-3 Groundwater Operable Unit

Analyte Name[a]	Exposure Point Concentration (µg/L or pCi/L)[a]	Analyte Name[a]	Exposure Point Concentration (µg/L or pCi/L)[a]
1,2-Dichloroethane	0.10	Lithium	35
1,4-Dichlorobenzene	0.24	Manganese	6.0
1,4-Dioxane	7.6	Molybdenum	7.9
Acetone	1.3	Nickel	5.0
Aluminum	22	Nitrate	109,500
Americium-241	0.13	Plutonium-238	0.24
Arsenic	9.0	Plutonium-239/240	0.70
Barium	110	Selenium	4.2
Boron	136	Strontium	930
Bromomethane	0.51	Strontium-90	3.3
Carbon-14	12	Styrene	0.14
Chloride	36,600	Sulfate	127,000
Chlorobenzene	0.15	Technetium-99	6.1
Chloroform	0.46	Tetrachloroethene	0.18
Chloromethane	0.077	Tin	0.10
Chromium	26	Toluene	0.072
Cobalt	0.17	Trichloroethene	11
Copper	2.3	Trichloromonofluoromethane	0.11
Fluoride	520	Tritium	2,700
Gross alpha	6.2	Vanadium	17
Hexavalent Chromium	20	Xylenes (total)	0.20
Iron	83	Zinc	6.0
Lead	0.20		

Notes:

a. 90th percentile groundwater concentration calculated as described in ECF-100FR3-11-0024.

Table 4-4. Toxicity Criteria for 100-FR-3 Groundwater Analytes

Analyte Name[a]	Oral Reference Dose (RfD_o)[b] (mg/kg-day)	Key	Oral Cancer Slope Factor (CSF_o)[b] $(mg/kg\text{-}day)^{-1}$ or Oral Slope Factor (SF_o)[c] (Risk/pCi)	Key	Inhalation Unit Risk (IUR)[b] $(\mu g/m^3)^{-1}$	Key	Inhalation Cancer Slope Factor (CSF_i)[d] (kg-day/mg) or Inhalation Slope Factor (SF_i)[c] (Risk/pCi)	Inhalation Reference Concentration (RfC_i)[b] (mg/m^3)	Key	Inhalation Reference Dose (RfD_i)[e] (mg/kg-day)	Volatile Nonradionuclides[b] Radionuclides[a]	GIABS Nonradionuclides[b] Radionuclides[c]	K_p[f] (cm/hour)	B[f]	τ[f] (hours/event)	t^*[f] (hours)	FA[f]
1,2-Dichloroethane	6.00E-03	X	9.10E-02	I	2.60E-05	I	9.10E-02	7.00E-03	P	2.00E-03	V	1.00E+00	0.0042	0	0.38	0.92	1
1,4-Dichlorobenzene	7.00E-02	A	5.40E-03	C	1.10E-05	C	3.85E-02	8.00E-01	I	2.29E-01	V	1.00E+00	0.042	0.2	0.71	1.71	1
1,4-Dioxane	3.00E-02	I	1.00E-01	I	7.70E-08	C	2.70E-02	3.00E+00	C	8.57E-01	SV[h]	1.00E+00	0.00033	0	0.33	0.8	1
Acetone	9.00E-01	I	–	–	–	–	–	3.10E+01	A	8.86E+00	V	1.00E+00	0.000512[g]	–	–	–	–
Aluminum	1.00E+00	P	–	–	–	–	–	5.00E-03	P	1.43E-03	–	1.00E+00	0.001	–	–	–	–
Americium-241	–	–	1.04E-10	H	–	–	2.81E-08	–	–	–	–	–	–	–	–	–	–
Arsenic	3.00E-04	I	1.50E+00	I	4.30E-03	I	1.51E+01	1.50E-05	C	4.29E-06	–	1.00E+00	0.001	–	–	–	–
Barium	2.00E-01	I	–	–	–	–	–	5.00E-04	H	1.43E-04	–	7.00E-02	0.001	–	–	–	–
Boron	2.00E-01	I	–	–	–	–	–	2.00E-02	H	5.71E-03	–	1.00E+00	0.001	–	–	–	–
Bromomethane	1.40E-03	I	–	–	–	–	–	5.00E-03	I	1.43E-03	V	1.00E+00	0.0028	0	0.36	0.87	1
Carbon-14	–	–	1.55E-12	H	–	–	7.07E-12	–	–	–	–	–	–	–	–	–	–
Chloride	–	–	–	–	–	–	–	–	–	–	–	–	0.001	–	–	–	–
Chlorobenzene	2.00E-02	I	–	–	–	–	–	5.00E-02	P	1.43E-02	V	1.00E+00	0.028	0.1	0.48	1.09	1
Chloroform	1.00E-02	I	3.10E-02	C	2.30E-05	I	8.05E-02	9.80E-02	A	2.80E-02	V	1.00E+00	0.0088	0	0.5	1.19	1
Chloromethane	–	–	–	–	–	–	–	9.00E-02	I	2.57E-02	V	1.00E+00	0.0033	0	0.2	0.49	1
Chromium	1.50E+00	I	–	–	–	–	–	–	–	–	–	1.30E-02	0.001	–	–	–	–
Cobalt	3.00E-04	P	–	–	9.00E-03	P	3.15E+01	6.00E-06	P	1.71E-06	–	1.00E+00	0.0004	–	–	–	–
Copper	4.00E-02	H	–	–	–	–	–	–	–	–	–	1.00E+00	0.001	–	–	–	–
Fluoride	6.00E-02	I	–	–	–	–	–	1.30E-02	C	3.71E-03	–	1.00E+00	0.001	–	–	–	–
Gross alpha	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hexavalent Chromium	3.00E-03	I	–	–	8.40E-02	S	2.94E+02	1.00E-04	I	2.86E-05	–	2.50E-02	0.002	–	–	–	–
Iron	7.00E-01	P	–	–	–	–	–	–	–	–	–	1.00E+00	0.001	–	–	–	–
Lead	–	–	–	–	–	–	–	–	–	–	–	1.00E+00	0.0001	–	–	–	–
Lithium	2.00E-03	P	–	–	–	–	–	–	–	–	–	1.00E+00	0.001	–	–	–	–
Manganese	2.40E-02	S	–	–	–	–	–	5.00E-05	I	1.43E-05	–	4.00E-02	0.001	–	–	–	–
Molybdenum	5.00E-03	I	–	–	–	–	–	–	–	–	–	1.00E+00	0.001	–	–	–	–

Table 4-4. Toxicity Criteria for 100-FR-3 Groundwater Analytes

Analyte Name[a]	Oral Reference Dose (RfD_o)[b] (mg/kg-day)	Key	Oral Cancer Slope Factor (CSF_o)[b] $(mg/kg\text{-}day)^{-1}$ or Oral Slope Factor (SF_o)[c] (Risk/pCi)	Key	Inhalation Unit Risk (IUR)[b] $(\mu g/m^3)^{-1}$	Key	Inhalation Cancer Slope Factor (CSF_i)[d] (kg-day/mg) or Inhalation Slope Factor (SF_i)[c] (Risk/pCi)	Inhalation Reference Concentration (RfC)[b] (mg/m^3)	Key	Inhalation Reference Dose (RfD_i)[e] (mg/kg-day)	Volatile Nonradionuclides[b] Radionuclides[e]	GIABS Nonradionuclides[b] Radionuclides[e]	K_p[f] (cm/hour)	B[f]	τ[f] (hours/event)	t^*[f] (hours)	FA[f]
Nickel	2.00E-02	I	--	--	2.60E-04	C	9.10E-01	9.00E-05	A	2.57E-05	--	4.00E-02	0.0002	--	--	--	--
Nitrate	7.10E+00	I	--	--	--	--	--	--	--	--	--	1.00E+00	0.001	--	--	--	--
Plutonium-238	--	--	1.31E-10	H	--	--	3.36E-08	--	--	--	--	--	--	--	--	--	--
Plutonium-239/240[i]	--	--	1.35E-10	H	--	--	3.33E-08	--	--	--	--	--	--	--	--	--	--
Selenium	5.00E-03	I	--	--	--	--	--	2.00E-02	C	5.71E-03	--	1.00E+00	0.001	--	--	--	--
Strontium	6.00E-01	I	--	--	--	--	--	--	--	--	--	1.00E+00	0.001	--	--	--	--
Strontium-90	--	--	5.59E-11	H	--	--	1.05E-10	--	--	--	--	--	--	--	--	--	--
Styrene	2.00E-01	I	--	--	--	--	--	1.00E+00	I	2.86E-01	V	1.00E+00	0.037	0.1	0.41	0.98	1
Sulfate	--	--	--	--	--	--	--	--	--	--	--	--	0.001	--	--	--	--
Technetium-99	--	--	2.75E-12	H	--	--	1.41E-11	--	--	--	--	--	--	--	--	--	--
Tetrachloroethene	6.00E-03	I	2.10E-03	I	2.60E-07	I	9.10E-04	4.00E-02	I	1.14E-02	V	1.00E+00	0.033	0.2	0.91	2.18	1
Tin	6.00E-01	H	--	--	--	--	--	--	--	--	--	1.00E+00	0.001	--	--	--	--
Toluene	8.00E-02	I	--	--	--	--	--	5.00E+00	I	1.43E+00	V	1.00E+00	0.031	0.1	0.35	0.84	1
Trichloroethene	5.00E-04	I	4.60E-02	I	4.10E-06	I	1.44E-02	2.00E-03	I	5.71E-04	V	1.00E+00	0.012	0.1	0.58	1.39	1
Trichloromonofluoromethane	3.00E-01	I	--	--	--	--	--	7.00E-01	H	2.00E-01	V	1.00E+00	0.013	0.1	0.63	1.51	1
Tritium	--	--	5.07E-14	H	--	--	5.62E-14	--	--	--	V	--	--	--	--	--	--
Vanadium	5.00E-03	S	--	--	--	--	--	--	--	--	--	1.00E+00	0.001	--	--	--	--
Xylenes (total)	2.00E-01	I	--	--	--	--	--	1.00E-01	I	2.86E-02	V	1.00E+00	0.053	0.2	0.42	1.01	1
Zinc	3.00E-01	I	--	--	--	--	--	--	--	--	--	1.00E+00	0.0006	--	--	--	--

Table 4-4. Toxicity Criteria for 100-FR-3 Groundwater Analytes

Analyte Name[a]	Oral Reference Dose (RfD_o)[b] (mg/kg-day)	Key	Oral Cancer Slope Factor (CSF_o)[b] $(mg/kg\text{-}day)^{-1}$ or Oral Slope Factor (SF_o)[c] (Risk/pCi)	Key	Inhalation Unit Risk (IUR)[b] $(\mu g/m^3)^{-1}$	Key	Inhalation Cancer Slope Factor (CSF_i)[d] (kg-day/mg) or Inhalation Slope Factor (SF_i)[d] (Risk/pCi)	Inhalation Reference Concentration (RfC)[b] (mg/m^3)	Key	Inhalation Reference Dose (RfD_i)[e] (mg/kg-day)	Volatile Nonradionuclides[h] Radionuclides[c]	GIABS Nonradionuclides[b] Radionuclides[c]	K_p[f] (cm/hour)	B[f]	τ[f] (hours/event)	t*[f] (hours)	FA[f]

Notes:

a. Source = ECF-100FR3-11-0024.

b. Source = EPA, 2012.

c. Source = EPA, 2001.

d. CSF_i (kg-day/mg) = IUR ($m^3/\mu g$) x 1/20 (m^3/day) x 70 (kg) x 1000 ($\mu g/mg$)

e. RfD_i (mg/kg-day) = RfC (mg/m^3) x 20 (m^3/day) x 1/70 (kg)

f. Source = EPA/540/R/99/005, Exhibits 3-1 (inorganic analytes) and B-3 (organic analytes).

g. Source = ORNL, 2013.

h. Defined as a semi-volatile per EPA SW-846 Method 8270 for semi-volatiles

i. Values presented are for plutonium-239; plutonium-239 is assumed to be the dominant isotope in undifferentiated plutonium-239/240

-- = indicates toxicity value not available for this contaminant and exposure route.

A = ATSDR

B = partitioning constant.

C = Cal EPA

FA = fraction absorbed.

GIABS = gastrointestinal absorption factor.

H = HEAST

I = IRIS

K_p = dermal permeability constant.

P = PPRTV

t* = time to reach steady-state.

τ = lag time

V = volatile

S = Special case chemical; basis for value discussed on EPA Regional Screening Levels website (EPA, 2012)

SV= Semivolatile

X = PPRTV Appendix

ECF-100FR3-11-0024 , *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit.*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

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EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

ORNL, 2013, The Risk Assessment Information System (RAIS).

Table 6-1. Worksheets for the CTUIR Drinking Water Exposure Pathway Calculations

100-FR-3 Groundwater Operable Unit
Table A-1: Results Summary
Table A-2: Ingestion of Nonradioactive Analytes in Drinking Water
Table A-3: Inhalation of Volatile Nonradioactive Analytes in Drinking Water
Table A-4: Dermal Absorption of Nonradioactive Analytes in Drinking Water
Table A-5: Inhalation of Volatile Radioactive Analytes in Drinking Water
Table A-6: Ingestion of Radioactive Analytes in Drinking Water

Notes:
CTUIR = Confederated Tribes of the Umatilla Indian Reservation

Table 6-2. Worksheets for the Yakama Nation Drinking Water Exposure Pathway Calculations

100-FR-3 Groundwater Operable Unit
Table B-1: Results Summary
Table B-2: Ingestion of Nonradioactive Analytes in Drinking Water
Table B-3: Inhalation of Volatile Nonradioactive Analytes in Drinking Water
Table B-4: Dermal Absorption of Nonradioactive Analytes in Drinking Water
Table B-5: Inhalation of Volatile Radioactive Analytes in Drinking Water
Table B-6: Ingestion of Radioactive Analytes in Drinking Water

Table 6-3. Worksheets for the CTUIR Sweat Lodge Exposure Pathway Calculations

100-FR-3 Groundwater Operable Unit
Table C-1: Results Summary
Table C-2: Inhalation of Volatile and Semi-Volatile Analytes in Vapor
Table C-3: Inhalation of Nonvolatile Analytes in Vapor
Table C-4: Dermal Exposure to Volatile and Semi-Volatile Analytes in Vapor
Table C-5: Dermal Exposure to Nonvolatile Analytes in Condensed Water
Table C-6: Dermal Exposure to Nonvolatile Analytes in Vapor
Table C-7: Inhalation of Volatile and Semi-Volatile Radioactive Analytes in Vapor
Table C-8: Inhalation of Nonvolatile Radioactive Analytes in Vapor

Notes:

CTUIR = Confederated Tribes of the Umatilla Indian Reservation

Table 6-4. Worksheets for the Yakama Nation Sweat Lodge Exposure Pathway Calculations

100-FR-3 Groundwater Operable Unit
Table D-1: Results Summary With Aerosolized Nonvolatile Analytes
Table D-2: Results Summary Without Aerosolized Nonvolatile Analytes
Table D-3: Inhalation of Volatile and Semi-Volatile Analytes in Vapor
Table D-4: Inhalation of Nonvolatile Analytes in Vapor
Table D-5: Dermal Exposure to Volatile and Semi-Volatile Analytes in Vapor
Table D-6: Dermal Exposure to Nonvolatile Analytes in Condensed Water
Table D-7: Dermal Exposure to Nonvolatile Analytes in Vapor
Table D-8: Inhalation of Volatile and Semi-Volatile Radioactive Analytes in Vapor
Table D-9: Inhalation of Nonvolatile Radioactive Analytes in Vapor

Table 7-1. CTUIR Exposure Scenario—Summary of Risk Estimates from Use of Groundwater as a Potential Drinking Water Source

Exposure Route	100-FR-3 Groundwater Operable Unit	
	ELCR	HI
Nonradionuclide Analytes		
Ingestion	8.5E-04	6.3
Dermal	9.5E-06	0.20
Inhalation	3.5E-06	0.068
Total	8.6E-04	6.6
Radionuclide Analytes		
Ingestion	4.7E-05	--
Inhalation	1.2E-06	--
Total	4.9E-05	--
Total Cumulative ELCR[a]	9.1E-04	--

Notes:

a. Total Cumulative ELCR represents the sum of the total nonradionuclide ELCR and the total radionuclide ELCR.

CTUIR = Confederated Tribes of the Umatilla Indian Reservation

ELCR = excess lifetime cancer risk.

HI = hazard index.

-- = Indicates HI not applicable.

Table 7-2. CTUIR Exposure Scenario—Summary of Risk Estimates from Use of Groundwater in a Sweat Lodge

Exposure Route	100-FR-3 Groundwater Operable Unit	
	ELCR	HI
Nonradionuclide Analytes		
Inhalation in Sweat Lodge		
Volatile and Semi-Volatiles (vapor)	5.8E-06	0.28
Nonvolatile (aerosol)	1.4E-02	11
Total	1.4E-02	11
Dermal Exposure in Sweat Lodge		
Volatile and Semi-Volatiles (vapor only)	1.6E-09	<0.01
Nonvolatile (vapor and aqueous condensate)	3.4E-06	0.16
Total	3.4E-06	0.16
Total Nonradionuclide	1.4E-02	11
Radionuclide Analytes		
Inhalation in Sweat Lodge		
Volatile and Semi-Volatiles (vapor)	3.7E-06	--
Nonvolatile (aerosol)	1.5E-04	--
Total Radionuclide	1.5E-04	--
Total Cumulative ELCR[a]	1.4E-02	--

Notes:

a. Total Cumulative ELCR represents the sum of the total nonradionuclide ELCR and the total radionuclide ELCR.

-- = Indicates HI not applicable.

CTUIR = Confederated Tribes of the Umatilla Indian Reservation.

HI = hazard index.

ELCR = excess lifetime cancer risk.

Table 7-3. Yakama Nation Exposure Scenario—Summary of Risk Estimates from Use of Groundwater as a Potential Drinking Water Source

Exposure Route	100-FR-3 Groundwater Operable Unit	
	ELCR	HI
Nonradionuclide Analytes		
Ingestion	9.2E-04	6.3
Dermal	5.1E-06	0.20
Inhalation	7.4E-07	0.068
Total	9.3E-04	6.6
Radionuclide Analytes		
Ingestion	4.8E-05	--
Inhalation	1.3E-06	--
Total	5.0E-05	--
Total Cumulative ELCR[a]	9.8E-04	--

Notes:

a. Total Cumulative ELCR represents the sum of the total nonradionuclide ELCR and the total radionuclide ELCR.

ELCR = excess lifetime cancer risk.

HI = hazard index.

-- = Indicates HI not applicable.

Table 7-4. Yakama Nation Exposure Scenario—Summary of Risk Estimates from Use of Groundwater in a Sweat Lodge (With Aerosolized Nonvolatile Analytes)

Exposure Route	100-FR-3 Groundwater Operable Unit	
	ELCR	HI
Nonradionuclide Analytes		
Inhalation in Sweat Lodge		
Volatile and Semi-Volatiles (vapor)	4.3E-05	2.0
Nonvolatile (aerosol)	1.0E-01	79
Total	1.0E-01	81
Dermal Exposure in Sweat Lodge		
Volatile and Semi-Volatiles (vapor only)	1.1E-08	<0.01
Nonvolatile (vapor and aqueous condensate)	2.4E-05	1.1
Total	2.4E-05	1.1
Total Nonradionuclide	1.0E-01	82
Radionuclide Analytes		
Inhalation in Sweat Lodge		
Volatile and Semi-Volatiles (vapor)	2.8E-05	--
Nonvolatile (aerosol)	1.1E-03	--
Total Radionuclide	1.1E-03	--
Total Cumulative ELCR[a]	1.0E-01	--

Notes:

a. Total Cumulative ELCR represents the sum of the total nonradionuclide ELCR and the total radionuclide ELCR.

ELCR = excess lifetime cancer risk.

HI = hazard index.

-- = Indicates HI not applicable.

Table 7-5. Yakama Nation Exposure Scenario—Summary of Risk Estimates from Use of Groundwater in a Sweat Lodge (Without Aerosolized Nonvolatile Analytes)

Exposure Route	100-FR-3 Groundwater Operable Unit	
	ELCR	HI
Nonradionuclide Analytes		
Inhalation in Sweat Lodge		
Volatile and Semi-Volatiles (vapor)	1.3E-04	0.16
Nonvolatile (aerosol)	--	--
Total	1.3E-04	0.16
Dermal Exposure in Sweat Lodge		
Volatile and Semi-Volatiles (vapor only)	2.6E-08	<0.01
Nonvolatile (vapor and aqueous condensate)	2.4E-05[b]	1.1[b]
Total	2.4E-05	1.1
Total Nonradionuclide	1.5E-04	1.3
Radionuclide Analytes		
Inhalation in Sweat Lodge		
Volatile and Semi-Volatiles (vapor)	2.8E-05	--
Nonvolatile (aerosol)	--	--
Total Radionuclide	2.8E-05	--
Total Cumulative ELCR[a]	1.8E-04	--

Notes:

a. Total Cumulative ELCR represents the sum of the total nonradionuclide ELCR and the total radionuclide ELCR.

b. Aqueous condensate contribution only (vapor phase contribution excluded).

ELCR = excess lifetime cancer risk.

HI = hazard index.

-- = Indicates HI not applicable.

ATTACHMENT A

Attachment Table A-1. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of CTUIR Drinking Water Exposure Scenario Noncancer Hazard Results for Radioactive and Nonradioactive Analytes in Groundwater.

Nonradioactive Analyte Name	90th Percentile Concentration in Groundwater C_w (mg/L)	Volatile[a]	HQ (Ingestion)	HQ (Dermal)	HQ (Inhalation)	Total HQ	% Contribution
1,2-Dichloroethane	0.00010	Yes	9.52E-04	2.34E-05	1.78E-04	1.15E-03	0.017
1,4-Dichlorobenzene	0.00024	Yes	1.96E-04	8.57E-05	3.63E-06	2.85E-04	0.0040
1,4-Dioxane	0.0076	--	1.45E-03	2.80E-05	--[b]	1.48E-03	0.22
Acetone	0.0023	Yes	8.18E-05	--	5.01E-07	8.21E-05	0.0012
Aluminum	0.022	--	1.27E-03	3.32E-05	--[b]	1.27E-03	0.019
Arsenic	0.0080	--	1.71E+00	4.45E-03	--[b]	1.71E+00	25
Barium	0.11	--	3.14E-02	1.17E-03	--[b]	3.26E-02	0.49
Boron	0.14	--	3.28E-02	1.01E-04	--[b]	3.29E-02	0.49
Bromomethane	0.00051	Yes	2.08E-02	3.38E-04	1.12E-05	2.12E-02	0.34
Chloride	27	--	--	--	--[b]	--	--
Chlorobenzene	0.00015	Yes	4.28E-04	7.71E-05	3.63E-05	5.42E-04	0.008
Chloroform	0.00046	Yes	2.32E-03	1.18E-04	1.53E-03	2.77E-03	0.042
Chloromethane	0.000077	Yes	--	--	1.65E-05	1.65E-05	0.00025
Chromium	0.086	--	1.00E-03	2.01E-04	--[b]	1.20E-03	0.018
Cobalt	0.00017	--	3.30E-02	3.46E-05	--[b]	3.30E-02	0.50
Copper	0.0023	--	8.15E-05	6.74E-06	--[b]	8.88E-05	0.001
Fluoride	0.52	--	4.98E-01	1.28E-02	--[b]	4.98E-01	7.5
Hexavalent Chromium	0.020	--	3.82E-01	7.97E-02	--[b]	4.62E-01	7.0
Iron	0.083	--	6.76E-03	1.78E-05	--[b]	6.76E-03	0.10
Lead	0.00020	--	--	--	--[b]	--	--
Lithium	0.085	--	1.00E+00	2.61E-05	--[b]	1.00E+00	15
Manganese	0.0080	--	1.43E-02	8.32E-04	--[b]	1.52E-02	0.23
Molybdenum	0.0079	--	8.08E-02	2.37E-04	--[b]	8.08E-02	1.4
Nickel	0.0050	--	1.45E-02	1.88E-05	--[b]	1.45E-02	0.23
Nitrate	110	--	8.21E-01	2.50E-03	--[b]	8.24E-01	13
Selenium	0.0042	--	4.62E-01	1.25E-04	--[b]	4.62E-01	6.75
Strontium	0.88	--	8.85E-02	2.31E-04	--[b]	8.88E-02	1.3
Styrene	0.00014	Yes	3.86E-05	8.66E-06	1.83E-05	4.88E-05	0.00074
Sulfate	137	--	--	--	--[b]	--	--
Tetrachloroethene	0.00018	Yes	1.71E-05	5.11E-04	1.44E-05	2.28E-03	0.033
Tin	0.00010	--	9.52E-06	2.48E-08	--[b]	9.55E-06	0.00014
Toluene	0.000072	Yes	3.14E-08	9.88E-08	1.76E-07	6.06E-08	0.0009
Trichloroethene	0.011	Yes	1.28E+00	1.28E-01	6.05E-02	1.42E+00	22
Trichloromonofluoromethane	0.00011	Yes	2.10E-05	2.20E-06	1.98E-06	2.42E-05	0.00038
Vanadium	0.017	--	1.96E-01	3.07E-04	--[b]	1.96E-01	3.0
Xylenes (total)	0.00020	Yes	5.71E-06	1.30E-06	2.42E-06	9.38E-06	0.0015
Zinc	0.0080	--	1.14E-03	1.78E-06	--[b]	1.14E-03	0.017
Total HI			6.33E+00	2.04E-01	6.80E-02	6.60E+00	100

[a]Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b]Nonvolatile constituents are not considered in the inhalation exposure route
-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.
CTUIR = Confederated Tribes of the Umatilla Indian Reservation.
HI = hazard index.
HQ = hazard quotient.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of CTUIR Drinking Water Exposure Scenario Cancer Risk Results for Nonradioactive Analytes in Groundwater.

Nonradioactive Analyte Name	90th Percentile Concentration in Groundwater C_w (mg/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
1,2-Dichloroethane	0.00010	Yes	5.17E-07	1.59E-08	3.14E-08	5.73E-07	0.067
1,4-Dichlorobenzene	0.00024	Yes	7.91E-08	2.71E-08	3.18E-08	1.34E-07	0.016
1,4-Dioxane	0.0076	--	4.40E-08	8.53E-08	--[b]	4.41E-08	5.1
Acetone	0.0023	Yes	--	--	--	--	--
Aluminum	0.022	--	--	--	--[b]	--	--
Arsenic	0.0080	--	7.79E-04	2.28E-08	--[b]	7.81E-04	91
Barium	0.11	--	--	--	--[b]	--	--
Boron	0.14	--	--	--	--[b]	--	--
Bromomethane	0.00051	Yes	--	--	--	--	--
Chloride	27	--	--	--	--[b]	--	--
Chlorobenzene	0.00015	Yes	--	--	--	--	--
Chloroform	0.00046	Yes	8.18E-07	4.01E-08	1.28E-07	9.84E-07	0.11
Chloromethane	0.000077	Yes	--	--	--	--	--
Chromium	0.086	--	--	--	--[b]	--	--
Cobalt	0.00017	--	--	--	--[b]	--	--
Copper	0.0023	--	--	--	--[b]	--	--
Fluoride	0.52	--	--	--	--[b]	--	--
Hexavalent Chromium	0.020	--	--	--	--[b]	--	--
Iron	0.083	--	--	--	--[b]	--	--
Lead	0.00020	--	--	--	--[b]	--	--
Lithium	0.085	--	--	--	--[b]	--	--
Manganese	0.0080	--	--	--	--[b]	--	--
Molybdenum	0.0079	--	--	--	--[b]	--	--
Nickel	0.0050	--	--	--	--[b]	--	--
Nitrate	110	--	--	--	--[b]	--	--
Selenium	0.0042	--	--	--	--[b]	--	--
Strontium	0.88	--	--	--	--[b]	--	--
Styrene	0.00014	Yes	--	--	--	--	--
Sulfate	137	--	--	--	--[b]	--	--
Tetrachloroethene	0.00018	Yes	2.18E-08	7.04E-08	1.88E-10	2.89E-08	0.0034
Tin	0.00010	--	--	--	--[b]	--	--
Toluene	0.000072	Yes	--	--	--	--	--
Trichloroethene	0.011	Yes	2.86E-08	2.74E-08	5.46E-07	3.20E-08	3.8
Trichloromonofluoromethane	0.00011	Yes	--	--	--	--	--
Vanadium	0.017	--	--	--	--[b]	--	--
Xylenes (total)	0.00020	Yes	--	--	--	--	--
Zinc	0.0080	--	--	--	--[b]	--	--
Total Nonradionuclide ELCR			8.53E-04	5.17E-08	7.15E-07	8.58E-04	100

[a]Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b]Nonvolatile constituents are not considered in the inhalation exposure route
-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
CTUIR = Confederated Tribes of the Umatilla Indian Reservation.
ELCR = excess lifetime cancer risk.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of CTUIR Drinking Water Exposure Scenario Cancer Risk Results for Radioactive Analytes in Groundwater.

Radioactive Analyte Name	90th Percentile Concentration in Groundwater C_w (pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
Americium-241	0.13	--	1.39E-06	--	--[b]	1.39E-06	2.7
Carbon-14	12	--	1.78E-05	--	--[b]	1.78E-05	3.6
Gross alpha	6.2	--	--	--	--[b]	--	--
Plutonium-238	0.34	--	2.84E-06	--	--[b]	2.88E-06	6.1
Plutonium-238/240	0.70	--	9.00E-06	--	--[b]	9.00E-06	19
Strontium-90	1.3	--	1.76E-05	--	--[b]	1.76E-05	36
Technetium-99	6.1	--	1.61E-06	--	--[b]	1.61E-06	3.3
Tritium	2,700	Yes	1.31E-05	--	1.20E-06	1.43E-05	29
Total Radionuclide ELCR			4.71E-05	--	1.20E-06	4.85E-05	100

[a]Volatile radioactive contaminants as defined by EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."
[b]Nonvolatile constituents are not considered in the inhalation exposure route
-- = indicates radionuclide toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
CTUIR = Confederated Tribes of the Umatilla Indian Reservation.
ELCR = excess lifetime cancer risk.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of CTUIR Drinking Water Exposure Scenario Cancer Risk Results for Radioactive and Nonradionuclide Analytes in Groundwater.

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
1,2-Dichloroethane	0.00010	Yes	5.17E-07	1.59E-08	3.14E-08	5.73E-07	0.083
1,4-Dichlorobenzene	0.00024	Yes	7.91E-08	2.71E-08	3.18E-08	1.34E-07	0.015
1,4-Dioxane	0.0076	--	4.40E-08	8.53E-08	--[b]	4.41E-08	4.8
Acetone	0.0023	Yes	--	--	--	--	--
Aluminum	0.022	--	--	--	--[b]	--	--
Arsenic	0.0080	--	7.79E-04	2.28E-08	--[b]	7.81E-04	88
Barium	0.11	--	--	--	--[b]	--	--
Boron	0.14	--	--	--	--[b]	--	--
Bromomethane	0.00051	Yes	--	--	--	--	--
Chloride	27	--	--	--	--[b]	--	--
Chlorobenzene	0.00015	Yes	--	--	--	--	--
Chloroform	0.00046	Yes	8.18E-07	4.01E-08	1.28E-07	9.84E-07	0.11
Chloromethane	0.000077	Yes	--	--	--	--	--
Chromium	0.086	--	--	--	--[b]	--	--
Cobalt	0.00017	--	--	--	--[b]	--	--
Copper	0.0023	--	--	--	--[b]	--	--
Fluoride	0.52	--	--	--	--[b]	--	--
Hexavalent Chromium	0.020	--	--	--	--[b]	--	--
Iron	0.083	--	--	--	--[b]	--	--
Lead	0.00020	--	--	--	--[b]	--	--
Lithium	0.085	--	--	--	--[b]	--	--
Manganese	0.0080	--	--	--	--[b]	--	--
Molybdenum	0.0079	--	--	--	--[b]	--	--
Nickel	0.0050	--	--	--	--[b]	--	--
Nitrate	110	--	--	--	--[b]	--	--
Selenium	0.0042	--	--	--	--[b]	--	--
Strontium	0.88	--	--	--	--[b]	--	--
Styrene	0.00014	Yes	--	--	--	--	--
Sulfate	137	--	--	--	--[b]	--	--
Tetrachloroethene	0.00018	Yes	2.18E-08	7.04E-08	1.88E-10	2.89E-08	0.0003
Tin	0.00010	--	--	--	--[b]	--	--
Toluene	0.000072	Yes	--	--	--	--	--
Trichloroethene	0.011	Yes	2.86E-08	2.74E-08	5.46E-07	3.20E-08	3.6
Trichloromonofluoromethane	0.00011	Yes	--	--	--	--	--
Vanadium	0.017	--	--	--	--[b]	--	--
Xylenes (total)	0.00020	Yes	--	--	--	--	--
Zinc	0.0080	--	--	--	--[b]	--	--
Americium-241	0.13	--	1.39E-06	--	--[b]	1.39E-06	0.14
Carbon-14	12	--	1.78E-05	--	--[b]	1.78E-05	0.19
Gross alpha	6.2	--	--	--	--[b]	--	--
Plutonium-238	0.34	--	2.84E-06	--	--[b]	2.88E-06	0.32
Plutonium-238/240	0.70	--	9.00E-06	--	--[b]	9.00E-06	0.99
Strontium-90	1.3	--	1.76E-05	--	--[b]	1.76E-05	1.9
Technetium-99	6.1	--	1.61E-06	--	--[b]	1.61E-06	0.18
Tritium	2,700	Yes	1.31E-05	--	1.20E-06	1.43E-05	1.6
Total Cumulative ELCR			9.01E-04	5.17E-08	1.84E-06	9.08E-04	100

[a] Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites" or as defined by EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity,"
[b] Nonvolatile constituents are not considered in the inhalation exposure route.
-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.

Attachment Table A-2. Ingestion of Nonradioactive Analytes in Drinking Water - CTUIR
100-FR-3 Groundwater Operable Unit Native American Risk Assessment

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Chronic Daily Intake - nonradiological ingestion	CDI	Calculated Value	mg/kg-day	Equations 5 and 8
Contaminant concentration in groundwater	C_w	Analyte-specific	mg/L	ECF-100FR3-11-0024
Body Weight - adult	BW_a	70	kg	Harris and Harper, 2004
Body Weight - child	BW_c	15	kg	Harris and Harper, 2004
Water Ingestion Rate - adult	IRW_a	4	L/day	Harris, 2008
Water Ingestion Rate - child	IRW_c	1	L/day	Harris and Harper, 2004
Age-Adjusted Water Ingestion Rate - nonradiological	IRW_{adj}	4.057	L-year/kg-day	Equation 6
Exposure Frequency	EF	365	days/year	Harris and Harper, 2004
Exposure Duration - adult	ED_a	70	years	Harris and Harper, 2004
Exposure Duration - child	ED_c	6	years	Harris, 2008
Averaging time - carcinogens and noncarcinogens	AT	70	years	Harris, 2008
Reference Dose - Oral	RfD_o	Analyte-specific	mg/kg-day	EPA, 2012
Cancer Slope Factor - Oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	EPA, 2012
Conversion Factor	CF1	365	days/year	1 year = 365 days

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

Harris, S., and Harper, B., 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.

Harris, S., 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments*.

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	C_w (mg/L)	CDI (noncarcinogen) (mg/kg-day)	RfD_o* (mg/kg-day)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	0.00010	5.71E-06	6.00E-03	9.52E-04	0.015
1,4-Dichlorobenzene	106-46-7	0.00024	1.37E-05	7.00E-02	1.96E-04	0.0031
1,4-Dioxane	123-91-1	0.0076	4.34E-04	3.00E-02	1.45E-02	0.23
Acetone	67-64-1	0.0013	7.34E-05	9.00E-01	8.16E-05	0.0013
Aluminum	7429-90-5	0.022	1.27E-03	1.00E+00	1.27E-03	0.020
Arsenic	7440-38-2	0.0090	5.12E-04	3.00E-04	1.71E+00	27
Barium	7440-39-3	0.11	6.29E-03	2.00E-01	3.14E-02	0.50
Boron	7440-42-8	0.14	7.77E-03	2.00E-01	3.88E-02	0.61
Bromomethane	74-83-9	0.00081	2.86E-05	1.40E-03	2.04E-02	0.33
Chloride	16887-00-6	37	2.08E+00	--	--	--
Chlorobenzene	108-90-7	0.00015	8.57E-03	2.00E-02	4.29E-04	0.0068
Chloroform	67-66-3	0.00046	2.60E-05	1.00E-02	2.60E-03	0.041
Chloromethane	74-87-3	0.000077	4.40E-04	--	--	--
Chromium	7440-47-3	0.026	1.50E-03	1.50E+00	1.00E-03	0.016
Cobalt	7440-48-4	0.00017	9.88E-04	3.00E-04	3.30E-02	0.52
Copper	7440-50-8	0.0023	1.34E-04	4.00E-02	3.35E-03	0.053
Fluoride	16984-48-8	0.52	2.97E-02	6.00E-02	4.95E-01	7.8
Hexavalent Chromium	18540-29-9	0.020	1.15E-03	3.00E-02	3.82E-01	6.0
Iron	7439-89-6	0.083	4.71E-03	7.00E-01	6.73E-03	0.11
Lead	7439-92-1	0.00020	1.14E-05	--	--	--
Lithium	7439-93-2	0.035	2.00E-03	2.00E-03	1.00E+00	16
Manganese	7439-96-5	0.0060	3.48E-04	2.40E-02	1.43E-02	0.23
Molybdenum	7439-98-7	0.0079	4.53E-04	5.00E-03	9.06E-02	1.4
Nickel	7440-02-0	0.0050	2.86E-04	2.00E-02	1.43E-02	0.23
Nitrate	14797-55-8	110	6.28E+00	7.10E+00	8.81E-01	14
Selenium	7782-49-2	0.0042	2.40E-04	5.00E-03	4.81E-02	0.76
Strontium	7440-24-6	0.93	5.31E-02	6.00E-01	8.85E-02	1.4
Styrene	100-42-5	0.00014	7.71E-06	2.00E-01	3.86E-03	0.00061
Sulfate	14808-79-8	127	7.26E+00	--	--	--
Tetrachloroethene	127-18-4	0.00018	1.03E-05	6.00E-03	1.71E-03	0.027
Tin	7440-31-5	0.00010	5.71E-06	6.00E-01	9.52E-06	0.00015
Toluene	108-88-3	0.000072	4.11E-06	8.00E-02	5.14E-05	0.0006
Trichloroethene	79-01-6	0.011	6.29E-04	5.00E-04	1.26E+00	20
Trichloromonofluoromethane	75-69-4	0.00011	6.29E-04	3.00E-01	2.10E-03	0.00033
Vanadium	7440-62-2	0.017	9.71E-04	5.00E-03	1.94E-01	3.1
Xylenes (total)	1330-20-7	0.00020	1.14E-05	2.00E-01	5.71E-05	0.0009
Zinc	7440-66-6	0.0060	3.43E-04	3.00E-01	1.14E-03	0.018
Total HI					6.33E+00	100

*EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.

HI = hazard index.

HQ = hazard quotient.

EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final.*

Cancer risk calculation

Nonradioactive Analyte	CAS #	C_w (mg/L)	CDI (carcinogen) (mg/kg-day)	CSF_o* $(mg/kg\text{-}day)^{-1}$	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	0.00010	5.80E-04	9.10E-02	5.27E-07	0.062
1,4-Dichlorobenzene	106-46-7	0.00024	1.38E-05	5.40E-03	7.51E-08	0.0088
1,4-Dioxane	123-91-1	0.0076	4.40E-04	1.00E-01	4.40E-05	5.2
Acetone	67-64-1	0.0013	7.45E-05	--	--	--
Aluminum	7429-90-5	0.022	1.29E-03	--	--	--
Arsenic	7440-38-2	0.0090	5.19E-04	1.50E+00	7.79E-04	91
Barium	7440-39-3	0.11	6.38E-03	--	--	--
Boron	7440-42-8	0.14	7.88E-03	--	--	--
Bromomethane	74-83-9	0.00081	2.93E-05	--	--	--
Chloride	16887-00-6	37	2.12E+00	--	--	--
Chlorobenzene	108-90-7	0.00015	8.68E-06	--	--	--
Chloroform	67-66-3	0.00046	2.64E-05	3.10E-02	8.18E-07	0.096
Chloromethane	74-87-3	0.000077	4.46E-06	--	--	--
Chromium	7440-47-3	0.026	1.52E-03	--	--	--
Cobalt	7440-48-4	0.00017	1.00E-03	--	--	--
Copper	7440-50-8	0.0023	1.36E-04	--	--	--
Fluoride	16984-48-8	0.52	3.01E-02	--	--	--
Hexavalent Chromium	18540-29-9	0.020	1.16E-03	--	--	--
Iron	7439-89-6	0.083	4.78E-03	--	--	--
Lead	7439-92-1	0.00020	1.16E-05	--	--	--
Lithium	7439-93-2	0.035	2.03E-03	--	--	--
Manganese	7439-96-5	0.0060	3.48E-04	--	--	--
Molybdenum	7439-98-7	0.0079	4.60E-04	--	--	--
Nickel	7440-02-0	0.0050	2.90E-04	--	--	--
Nitrate	14797-55-8	110	6.35E+00	--	--	--
Selenium	7782-49-2	0.0042	2.44E-04	--	--	--
Strontium	7440-24-6	0.93	5.39E-02	--	--	--
Styrene	100-42-5	0.00014	7.82E-06	--	--	--
Sulfate	14808-79-8	127	7.36E+00	--	--	--
Tetrachloroethene	127-18-4	0.00018	1.04E-05	2.10E-03	2.19E-08	0.003
Tin	7440-31-5	0.00010	5.80E-06	--	--	--
Toluene	108-88-3	0.000072	4.17E-06	--	--	--
Trichloroethene	79-01-6	0.011	6.38E-04	4.60E-02	2.93E-05	3.4
Trichloromonofluoromethane	75-69-4	0.00011	6.38E-06	--	--	--
Vanadium	7440-62-2	0.017	9.85E-04	--	--	--
Xylenes (total)	1330-20-7	0.00020	1.16E-05	--	--	--
Zinc	7440-66-6	0.0060	3.48E-04	--	--	--
Total Nonradionuclide ELCR					8.53E-04	100

*EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final.*

Attachment A-3. Inhalation of Volatile Nonradioactive Analytes in Drinking Water - CTUIR
100-FR-3 Groundwater Operable Unit Native American Risk Assessment

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Chronic Daily Intake - nonradiological inhalation	CDI	Calculated Value	mg/m^3 for noncarcinogens, $\mu g/m^3$ for carcinogens	Equations 13 and 15
Contaminant concentration in groundwater	C_w	Analyte-specific	mg/L	ECF-100FR3-11-0024
Exposure Time- adult	ET_a	0.58	hours/day	EPA/540/R/99/005
Exposure Frequency	EF	365	days/year	Harris and Harper, 2004
Exposure Duration - adult	ED_a	70	years	Harris and Harper, 2004
Averaging time - carcinogens and noncarcinogens	AT	70	years	Harris, 2008
Volatilization Factor	VF	0.5	L/m^3	EPA/540/R-92/003
Reference Concentration	RfC	Analyte-specific	mg/m^3	EPA, 2012
Inhalation Unit Risk	IUR	Analyte-specific	$(\mu g/m^3)^{-1}$	EPA, 2012
Conversion Factor	CF1	365	days/year	1 year = 365 days
Conversion Factor	CF2	1/24	days/hour	1 day = 24 hours

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim.*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final*

EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

Harris, S., and Harper, B., 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways .*

Harris, S., 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments .*

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_w (mg/L)	CDI (noncarcinogen) (mg/m^3)	RfC[a] (mg/m^3)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	1.21E-06	7.00E-03	1.73E-04	0.25
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	2.90E-06	8.00E-01	3.63E-06	0.005
1,4-Dioxane	123-91-1	--	0.0076	--[b]	3.00E+00	--[b]	--
Acetone	67-64-1	Yes	0.0013	1.55E-05	3.10E+01	5.01E-07	0.0007
Aluminum	7429-90-5	--	0.022	--[b]	5.00E-05	--[b]	--
Arsenic	7440-38-2	--	0.0080	--[b]	1.50E-05	--[b]	--
Barium	7440-39-3	--	0.11	--[b]	5.00E-04	--[b]	--
Boron	7440-42-8	--	0.14	--[b]	2.00E-02	--[b]	--
Bromomethane	74-83-9	Yes	0.00051	6.10E-06	5.00E-03	1.22E-03	2
Chloride	16887-00-6	--	37	--[b]	--	--[b]	--
Chlorobenzene	108-90-7	Yes	0.00015	1.81E-06	5.00E-02	3.63E-05	0.05
Chloroform	67-66-3	Yes	0.00044	5.50E-06	9.80E-02	5.61E-05	0.1
Chloromethane	74-87-3	Yes	0.000077	9.30E-07	9.00E-02	1.03E-05	0.02
Chromium	7440-47-3	--	0.026	--[b]	--	--[b]	--
Cobalt	7440-48-4	--	0.00017	--[b]	6.00E-06	--[b]	--
Copper	7440-50-8	--	0.0023	--[b]	--	--[b]	--
Fluoride	16984-48-8	--	0.52	--[b]	1.30E-02	--[b]	--
Hexavalent Chromium	18540-29-9	--	0.020	--[b]	1.00E-04	--[b]	--
Iron	7439-89-6	--	0.083	--[b]	--	--[b]	--
Lead	7439-92-1	--	0.00020	--[b]	--	--[b]	--
Lithium	7439-93-2	--	0.085	--[b]	--	--[b]	--
Manganese	7439-96-5	--	0.0080	--[b]	5.00E-05	--[b]	--
Molybdenum	7439-98-7	--	0.0079	--[b]	--	--[b]	--
Nickel	7440-02-0	--	0.0050	--[b]	9.00E-05	--[b]	--
Nitrate	14797-55-8	--	110	--[b]	--	--[b]	--
Selenium	7782-49-2	--	0.0042	--[b]	2.00E-02	--[b]	--
Strontium	7440-24-6	--	0.83	--[b]	--	--[b]	--
Styrene	100-42-5	Yes	0.00014	1.63E-06	1.00E+00	1.63E-06	0.002
Sulfate	14808-79-8	--	127	--[b]	--	--[b]	--
Tetrachloroethene	127-18-4	Yes	0.00018	2.18E-06	4.00E-02	5.44E-05	0.08
Tin	7440-31-5	--	0.00010	--[b]	--	--[b]	--
Toluene	108-88-3	Yes	0.000072	8.70E-07	5.00E+00	1.74E-07	0.0008
Trichloroethene	79-01-6	Yes	0.011	1.33E-04	2.00E-03	6.65E-02	98
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.33E-06	7.00E-01	1.90E-06	0.003
Vanadium	7440-62-2	--	0.017	--[b]	--	--[b]	--
Xylenes (total)	1330-20-7	Yes	0.00020	2.42E-06	1.00E-01	2.42E-05	0.04
Zinc	7440-66-6	--	0.0080	--[b]	--	--[b]	--
Total HI						6.80E-02	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b]Nonvolatile constituents are not considered in the inhalation exposure route

-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.

HI = hazard index.

HQ = hazard quotient.

EPA-540-R-070-002, *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).*

Cancer risk calculation

Nonradioactive Analyte	CAS #	Volatile[a]	C_w (mg/L)	CDI (cancer) ($\mu g/m^3$)	IUR[a] $(\mu g/m^3)^{-1}$	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	1.21E-03	2.60E-05	3.14E-08	4.3
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	2.90E-03	1.10E-05	3.19E-08	4.3
1,4-Dioxane	123-91-1	--	0.0076	--[b]	7.70E-06	--[b]	--
Acetone	67-64-1	Yes	0.0013	1.55E-02	--	--	--
Aluminum	7429-90-5	--	0.022	--[b]	--	--[b]	--
Arsenic	7440-38-2	--	0.0080	--[b]	4.30E-03	--[b]	--
Barium	7440-39-3	--	0.11	--[b]	--	--[b]	--
Boron	7440-42-8	--	0.14	--[b]	--	--[b]	--
Bromomethane	74-83-9	Yes	0.00051	6.10E-03	--	--	--
Chloride	16887-00-6	--	37	--[b]	--	--[b]	--
Chlorobenzene	108-90-7	Yes	0.00015	1.81E-03	--	--	--
Chloroform	67-66-3	Yes	0.00044	5.50E-03	2.30E-05	1.26E-07	17
Chloromethane	74-87-3	Yes	0.000077	9.30E-04	--	--	--
Chromium	7440-47-3	--	0.026	--[b]	--	--[b]	--
Cobalt	7440-48-4	--	0.00017	--[b]	9.00E-05	--[b]	--
Copper	7440-50-8	--	0.0023	--[b]	--	--[b]	--
Fluoride	16984-48-8	--	0.52	--[b]	--	--[b]	--
Hexavalent Chromium	18540-29-9	--	0.020	--[b]	8.40E-02	--[b]	--
Iron	7439-89-6	--	0.083	--[b]	--	--[b]	--
Lead	7439-92-1	--	0.00020	--[b]	--	--[b]	--
Lithium	7439-93-2	--	0.085	--[b]	--	--[b]	--
Manganese	7439-96-5	--	0.0080	--[b]	--	--[b]	--
Molybdenum	7439-98-7	--	0.0079	--[b]	--	--[b]	--
Nickel	7440-02-0	--	0.0050	--[b]	2.60E-04	--[b]	--
Nitrate	14797-55-8	--	110	--[b]	--	--[b]	--
Selenium	7782-49-2	--	0.0042	--[b]	--	--[b]	--
Strontium	7440-24-6	--	0.83	--[b]	--	--[b]	--
Styrene	100-42-5	Yes	0.00014	1.63E-03	--	--	--
Sulfate	14808-79-8	--	127	--[b]	--	--[b]	--
Tetrachloroethene	127-18-4	Yes	0.00018	2.18E-03	2.60E-07	5.66E-10	0.08
Tin	7440-31-5	--	0.00010	--[b]	--	--[b]	--
Toluene	108-88-3	Yes	0.000072	8.70E-04	--	--	--
Trichloroethene	79-01-6	Yes	0.011	1.33E-01	4.10E-06	5.45E-07	74
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.33E-03	--	--	--
Vanadium	7440-62-2	--	0.017	--[b]	--	--[b]	--
Xylenes (total)	1330-20-7	Yes	0.00020	2.42E-03	--	--	--
Zinc	7440-66-6	--	0.0080	--[b]	--	--[b]	--
Total Nonradionuclide ELCR						7.35E-07	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b]Nonvolatile constituents are not considered in the inhalation exposure route

-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

EPA-540-R-070-002, *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).*

Attachment Table A-4. Dermal Absorption of Nonradioactive Analytes in Drinking Water - CTUIR
100-FR-3 Groundwater Operable Unit Native American Risk Assessment

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Chronic Daily Intake - Dermal	CDI	calculated	mg/kg-day	Equations 21 and 24
Contaminant concentration in groundwater	C_w	Analyte-specific	mg/L	ECF-100FR3-11-0024
Body Weight - adult	BW_a	70	kg	Harris and Harper, 2004
Body Weight - child	BW_c	15	kg	Harris and Harper, 2004
Exposure Time - adult	ET_a	0.58	hours/event	EPA/540/R/99/005
Exposure Time - child	ET_c	1	hours/event	EPA/540/R/99/005
Age Adjusted Exposure Time	ET_{adj}	0.616	hours/event	Equation 20
Skin Surface Area - adult	SA_a	18,000	cm^2	EPA/540/R/99/005
Skin Surface Area - child	SA_c	6,600	cm^2	EPA/540/R/99/005
Age Adjusted Skin Surface Area	SA_{adj}	19,097	(cm^2-year-event)/(kg-day)	Equation 22
Event Frequency - adult	EV_a	1	event/day	EPA/540/R/99/005
Event Frequency - child	EV_c	1	event/day	EPA/540/R/99/005
Exposure Frequency	EF	365	days/year	Harris and Harper, 2004
Exposure Duration - adult	ED_a	70	years	Harris and Harper, 2004
Exposure Duration - child	ED_c	6	years	Harris, 2008
Averaging Time - carcinogens and noncarcinogens	AT	70	years	Harris, 2008
Reference Dose - Oral	RfD_o	Analyte-specific	mg/kg-day	EPA, 2012
Cancer Slope Factor - Oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	EPA, 2012
Gastrointestinal Absorption Factor	GIABS	Analyte-specific	unitless	EPA, 2012
Conversion Factor	CF1	365	days/year	1 year = 365 days
Conversion Factor	CF5	0.001	L/cm^3	1 L = 1000 cm^3
The constant pi	π	3.14159	unitless	--
Time to reach steady state conditions	t*	Analyte-specific	hours	EPA/540/R/99/005
Partitioning Constant derived by Bunge Model	B	Analyte-specific	unitless	EPA/540/R/99/005
Absorbed Dose per Event	DA_{event}	calculated	mg/cm^2-event	Equations 27, 28, and 29
Dermal Permeability Coefficient	K_p	Analyte-specific	cm/hour	EPA/540/R/99/005
Fraction of absorbed water	FA	Analyte-specific	unitless	EPA/540/R/99/005
Lag Time	τ	Analyte-specific	hours/event	EPA/540/R/99/005

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*
EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim.*
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*
EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites"
Harris, S., and Harper, B., 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.
Harris, S., 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments*.

Absorbed Dermal Dose Calculation

100-FR-3 Operable Unit Native American Risk Assessment - Dermal Absorbed Dose Calculations										
Nonradioactive Analyte Name	CAS #	C_w (mg/L)	inorganic/organic[a]	FA[b] (unitless)	K_p[c] (cm/hour)	B[b] (unitless)	τ[b] (hours/event)	t*[b] (hours)	DA (noncancer) (mg/cm^2-event)	DA (cancer) (mg/cm^2-event)
1,2-Dichloroethane	107-06-2	0.00010	--	1	[illegible]	0	0.38	0.92	[illegible]	[illegible]
1,4-Dichlorobenzene	106-46-7	0.00004	--	1	[illegible]	0.2	0.71	1.71	[illegible]	[illegible]
1,4-Dioxane	123-91-1	0.0076	--	1	[illegible]	0	0.33	0.8	[illegible]	[illegible]
Acetone[c]	67-64-1	0.0013	--	--	[illegible]	--	--	--	--	--
Aluminum	7429-90-5	0.020	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Arsenic	7440-38-2	0.0050	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Barium	7440-39-3	0.11	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Boron	7440-42-8	0.14	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Bromomethane	74-83-9	0.00001	--	1	[illegible]	0	[illegible]	0.87	[illegible]	[illegible]
Chloride	16887-00-6	37	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Chlorobenzene	108-90-7	0.00015	--	1	[illegible]	0.1	0.46	1.09	[illegible]	[illegible]
Chloroform	67-66-3	0.00046	--	1	[illegible]	0	0.5	1.19	[illegible]	[illegible]
Chloromethane	74-87-3	0.000077	--	1	[illegible]	0	0.2	0.48	[illegible]	[illegible]
Chromium	7440-47-3	0.025	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Cobalt	7440-48-4	0.00017	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Copper	7440-50-8	0.0025	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Fluoride	16984-48-8	0.32	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Hexavalent Chromium	18540-29-9	0.010	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Iron	7439-89-6	0.031	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Lead	7439-92-1	0.00020	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Lithium	7439-93-2	0.020	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Manganese	7439-96-5	0.0050	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Molybdenum	7439-98-7	0.0079	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Nickel	7440-02-0	0.0050	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Nitrate	14797-55-8	110	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Selenium	7782-49-2	0.0042	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Strontium	7440-24-6	0.55	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Styrene	100-42-5	0.00054	--	1	[illegible]	0.1	0.41	0.98	[illegible]	[illegible]
Sulfate	14808-79-8	127	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Tetrachloroethene	127-18-4	0.00010	--	1	[illegible]	0.2	0.91	2.18	[illegible]	[illegible]
Tin	7440-31-5	0.00010	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Toluene	108-88-3	0.000072	--	1	[illegible]	0.1	0.35	0.84	[illegible]	[illegible]
Trichloroethene	79-01-6	0.011	--	1	[illegible]	0.1	0.58	1.39	[illegible]	[illegible]
Trichloromonofluoromethane	75-69-4	0.00011	--	1	[illegible]	0.1	0.88	2.01	[illegible]	[illegible]
Vanadium	7440-62-2	0.017	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Xylenes (total)	1330-20-7	0.00020	--	1	[illegible]	0.1	0.42	1.01	[illegible]	[illegible]
Zinc	7440-66-6	0.0050	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]

[a] EPA/540/R/99/005, Exhibit 3-1 (Inorganics) and Exhibit B-3
[b] EPA/540/R/99/005, Exhibit B-3
[c] The K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	C_w (mg/L)	CDI (noncarcinogen) (mg/kg-day)	RfD_o[a] (mg/kg-day)	GIABS[a] (unitless)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	0.00010	[illegible]	[illegible]	1.00E+00	[illegible]	0.011
1,4-Dichlorobenzene	106-46-7	0.00004	[illegible]	[illegible]	1.00E+00	[illegible]	0.003
1,4-Dioxane	123-91-1	0.0076	[illegible]	[illegible]	1.00E+00	[illegible]	0.010
Acetone	67-64-1	0.0013	--	[illegible]	1.00E+00	--	--
Aluminum	7429-90-5	0.020	[illegible]	1.00E+00	1.00E+00	[illegible]	[illegible]
Arsenic	7440-38-2	0.0050	[illegible]	[illegible]	1.00E+00	[illegible]	2.1
Barium	7440-39-3	0.11	[illegible]	[illegible]	7.00E-02	[illegible]	[illegible]
Boron	7440-42-8	0.14	[illegible]	[illegible]	1.00E+00	[illegible]	[illegible]
Bromomethane	74-83-9	0.00001	[illegible]	[illegible]	1.00E+00	[illegible]	0.16
Chloride	16887-00-6	37	[illegible]	--	--	--	--
Chlorobenzene	108-90-7	0.00015	[illegible]	2.00E-02	1.00E+00	[illegible]	[illegible]
Chloroform	67-66-3	0.00046	[illegible]	1.00E-02	1.00E+00	[illegible]	[illegible]
Chloromethane	74-87-3	0.000077	[illegible]	--	1.00E+00	--	--
Chromium	7440-47-3	0.025	[illegible]	1.50E+00	[illegible]	[illegible]	0.35
Cobalt	7440-48-4	0.00017	[illegible]	3.00E-04	1.00E+00	[illegible]	0.017
Copper	7440-50-8	0.0025	[illegible]	4.00E-02	1.00E+00	[illegible]	[illegible]
Fluoride	16984-48-8	0.32	[illegible]	[illegible]	1.00E+00	[illegible]	[illegible]
Hexavalent Chromium	18540-29-9	0.010	[illegible]	3.00E-03	2.50E-02	[illegible]	[illegible]
Iron	7439-89-6	0.031	[illegible]	7.00E-01	1.00E+00	[illegible]	[illegible]
Lead	7439-92-1	0.00020	[illegible]	--	1.00E+00	--	--
Lithium	7439-93-2	0.020	[illegible]	2.00E-03	1.00E+00	[illegible]	1.1
Manganese	7439-96-5	0.0050	[illegible]	2.40E-02	4.00E-02	[illegible]	0.45
Molybdenum	7439-98-7	0.0079	[illegible]	[illegible]	1.00E+00	[illegible]	0.12
Nickel	7440-02-0	0.0050	[illegible]	2.00E-02	4.00E-02	[illegible]	[illegible]
Nitrate	14797-55-8	110	[illegible]	1.60E+00	1.00E+00	[illegible]	1.1
Selenium	7782-49-2	0.0042	[illegible]	5.00E-03	1.00E+00	[illegible]	[illegible]
Strontium	7440-24-6	0.55	[illegible]	6.00E-01	1.00E+00	[illegible]	0.11
Styrene	100-42-5	0.00054	[illegible]	2.00E-01	1.00E+00	[illegible]	[illegible]
Sulfate	14808-79-8	127	[illegible]	--	--	--	--
Tetrachloroethene	127-18-4	0.00010	[illegible]	6.00E-03	1.00E+00	[illegible]	0.35
Tin	7440-31-5	0.00010	[illegible]	6.00E-01	1.00E+00	[illegible]	[illegible]
Toluene	108-88-3	0.000072	[illegible]	8.00E-02	1.00E+00	[illegible]	[illegible]
Trichloroethene	79-01-6	0.011	[illegible]	5.00E-04	1.00E+00	[illegible]	[illegible]
Trichloromonofluoromethane	75-69-4	0.00011	[illegible]	3.00E-01	1.00E+00	[illegible]	[illegible]
Vanadium	7440-62-2	0.017	[illegible]	5.04E-03	2.60E-02	[illegible]	0.16
Xylenes (total)	1330-20-7	0.00020	[illegible]	2.00E-01	1.00E+00	[illegible]	[illegible]
Zinc	7440-66-6	0.0050	[illegible]	3.00E-01	1.00E+00	[illegible]	[illegible]
Total HI						[illegible]	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites"
-- = Indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.
HI = hazard index
HQ = hazard quotient.
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	C_w (mg/L)	CDI (carcinogen) (mg/kg-day)	CSF_o[a] $(mg/kg\text{-}day)^{-1}$	GIABS[a] (unitless)	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	0.00010	[illegible]	9.10E-02	1.00E+00	[illegible]	0.27
1,4-Dichlorobenzene	106-46-7	0.00004	[illegible]	5.40E-03	1.00E+00	[illegible]	0.05
1,4-Dioxane	123-91-1	0.0076	[illegible]	1.00E-01	1.00E+00	[illegible]	1.6
Acetone	67-64-1	0.0013	--	--	1.00E+00	--	--
Aluminum	7429-90-5	0.020	[illegible]	--	1.00E+00	--	--
Arsenic	7440-38-2	0.0050	[illegible]	1.50E+00	1.00E+00	[illegible]	60
Barium	7440-39-3	0.11	[illegible]	--	7.00E-02	--	--
Boron	7440-42-8	0.14	[illegible]	--	1.00E+00	--	--
Bromomethane	74-83-9	0.00001	[illegible]	--	1.00E+00	--	--
Chloride	16887-00-6	37	[illegible]	--	--	--	--
Chlorobenzene	108-90-7	0.00015	[illegible]	--	1.00E+00	--	--
Chloroform	67-66-3	0.00046	[illegible]	3.10E-02	1.00E+00	[illegible]	0.70
Chloromethane	74-87-3	0.000077	[illegible]	--	1.00E+00	--	--
Chromium	7440-47-3	0.025	[illegible]	--	[illegible]	--	--
Cobalt	7440-48-4	0.00017	[illegible]	--	1.00E+00	--	--
Copper	7440-50-8	0.0025	[illegible]	--	1.00E+00	--	--
Fluoride	16984-48-8	0.32	[illegible]	--	1.00E+00	--	--
Hexavalent Chromium	18540-29-9	0.010	[illegible]	--	2.50E-02	--	--
Iron	7439-89-6	0.031	[illegible]	--	1.00E+00	--	--
Lead	7439-92-1	0.00020	[illegible]	--	1.00E+00	--	--
Lithium	7439-93-2	0.020	[illegible]	--	1.00E+00	--	--
Manganese	7439-96-5	0.0050	[illegible]	--	4.00E-02	--	--
Molybdenum	7439-98-7	0.0079	[illegible]	--	1.00E+00	--	--
Nickel	7440-02-0	0.0050	[illegible]	--	4.00E-02	--	--
Nitrate	14797-55-8	110	[illegible]	--	1.00E+00	--	--
Selenium	7782-49-2	0.0042	[illegible]	--	1.00E+00	--	--
Strontium	7440-24-6	0.55	[illegible]	--	1.00E+00	--	--
Styrene	100-42-5	0.00054	[illegible]	--	1.00E+00	--	--
Sulfate	14808-79-8	127	[illegible]	--	--	--	--
Tetrachloroethene	127-18-4	0.00010	[illegible]	2.10E-03	1.00E+00	[illegible]	0.14
Tin	7440-31-5	0.00010	[illegible]	--	1.00E+00	--	--
Toluene	108-88-3	0.000072	[illegible]	--	1.00E+00	--	--
Trichloroethene	79-01-6	0.011	[illegible]	4.60E-02	1.00E+00	[illegible]	35
Trichloromonofluoromethane	75-69-4	0.00011	[illegible]	--	1.00E+00	--	--
Vanadium	7440-62-2	0.017	[illegible]	--	2.60E-02	--	--
Xylenes (total)	1330-20-7	0.00020	[illegible]	--	1.00E+00	--	--
Zinc	7440-66-6	0.0050	[illegible]	--	1.00E+00	--	--
Total Nonradionuclide ELCR						[illegible]	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites"
-- = Indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

Attachment Table A-5. Inhalation of Volatile Radioactive Analytes in Drinking Water - CTUIR 100-FR-3 Groundwater Operable Unit Native American Risk Assessment

Intake Parameter Values				
Factor	Symbol	Value	Unit	Reference
Chronic Daily Intake - radiological inhalation	CDI	Calculated Value	pCi	Equation 17
Contaminant concentration in groundwater	C_w	Analyte-specific	pCi/L	ECF-100FR3-11-0024
Exposure frequency	EF	365	days/year	Harris and Harper, 2004
Exposure Duration - adult	ED_a	70	years	Harris and Harper, 2004
Exposure Duration - child	ED_c	6	years	Harris, 2008
Inhalation Rate - adult	INH_a	25	m^3/day	Harris, 2008
Inhalation Rate - child	INH_c	15	m^3/day	Harris, 2008
Age-adjusted Inhalation Rate - radiological	INH_RAD_{adj}	1690	m^3-year/day	Equation 18
Exposure Time - adult	ET_a	0.58	hour/day	EPA/540/R/99/005
Exposure Time - child	ET_c	1	hour/day	EPA/540/R/99/005
Age-Adjusted Exposure Time	ET_{adj}	0.616	hour/day	Equation 19
Conversion Factor	CF2	1/24	day/hour	1 day = 24 hours
Volatilization Factor	VF	0.5	L/m^3	EPA/540/R-92/003
Slope Factor - Inhalation	SF_i	Analyte-specific	risk/pCi	EPA, 2001

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim.*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

Harris, S., and Harper, B., 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.

Harris, S., 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments*.

Inhalation of Volatile Radioactive Constituents in Groundwater

Radioactive Analyte Name	CAS #	Volatile[a]	C_w (pCi/L)	CDI (radiological inhalation) (pCi)	SF_i[a] (risk/pCi)	Risk (unitless)	% Contribution
Americium-241	14596-10-2	--	0.13	--(b)	2.81E-08	--(b)	--
Carbon-14	14762-75-5	--	12	--(b)	7.07E-12	--(b)	--
Gross alpha	12587-46-1	--	6.2	--(b)	--	--(b)	--
Plutonium-238	13981-16-3	--	0.24	--(b)	3.36E-08	--(b)	--
Plutonium-239/240	15117-48-3	--	0.70	--(b)	3.33E-08	--(b)	--
Strontium-90	10098-97-2	--	3.3	--(b)	1.05E-10	--(b)	--
Technetium-99	14133-76-7	--	6.1	--(b)	1.41E-11	--(b)	--
Tritium	10028-17-8	Yes	2,700	2.14E+07	5.62E-14	1.20E-06	100
Total Radionuclide ELCR						1.20E-06	100

[a]EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

[b]Nonvolatile constituents are not considered in the inhalation exposure route

ELCR = excess lifetime cancer risk.

EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final.*

Attachment Table A-6. Ingestion of Radioactive Analytes in Drinking Water - CTUIR
100-FR-3 Groundwater Operable Unit Native American Risk Assessment

Intake Parameter Values				
Factor	Symbol	Value	Unit	Reference
Chronic Daily Intake - radiological ingestion	CDI	Calculated Value	pCi	Equation 10
Contaminant concentration in groundwater	C_w	Analyte-specific	pCi/L	ECF-100FR3-11-0024
Exposure frequency	EF	365	days/year	Harris and Harper, 2004
Exposure Duration - adult	ED_a	70	years	Harris and Harper, 2004
Exposure Duration - child	ED_c	6	years	Harris, 2008
Water Ingestion Rate - adult	IRW_a	4	L/day	Harris, 2008
Water Ingestion Rate - child	IRW_c	1	L/day	Harris and Harper, 2004
Age-adjusted water ingestion rate - radiological	IRW_RAD_{adj}	262	L-year/day	Equation 11
Slope Factor - oral	SF_o	Analyte-specific	risk/pCi	EPA, 2001

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*
EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."
Harris, S., and Harper, B., 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways* .
Harris, S., 2008, *Application of the CTUIR Traditional Ufeways Exposure Scenario in Hanford Risk Assessments* .

Ingestion of Radioactive Constituents in Groundwater

Radioactive Analyte Name	CAS #	C_w (pCi/L)	CDI (radiological ingestion) (pCi)	SF_o (risk/pCi)	Risk (unitless)	% Contribution
Americium-241	14596-10-2	0.13	1.24E+04	1.04E-10	1.29E-06	2.7
Carbon-14	14762-75-5	12	1.13E+06	1.55E-12	1.76E-06	3.7
Gross alpha	12587-46-1	6.2	5.88E+05	--	--	--
Plutonium-238	13981-16-3	0.24	2.25E+04	1.31E-10	2.94E-06	6.2
Plutonium-239/240	15117-48-3	0.70	6.67E+04	1.35E-10	9.00E-06	19
Strontium-90	10098-97-2	3.3	3.16E+05	5.59E-11	1.76E-05	37
Technetium-99	14133-76-7	6.1	5.84E+05	2.75E-12	1.61E-06	3.4
Tritium	10028-17-8	2,700	2.58E+08	5.07E-14	1.31E-05	28
Total Radionuclide ELCR					4.73E-05	100

ELCR = excess lifetime cancer risk.
EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final.*

ATTACHMENT B

Attachment Table B-1. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of Yakama Nation Drinking Water Exposure Scenario Noncancer Hazard Results for Radioactive and Nonradioactive Analytes in Groundwater.

Nonradioactive Analyte Name	90th Percentile Concentration in Groundwater C_w (mg/L)	Volatile[a]	HQ (Ingestion)	HQ (Dermal)	HQ (Inhalation)	Total HQ	% Contribution
1,2-Dichloroethane	0.00010	Yes	9.52E-04	2.34E-05	1.73E-04	1.15E-03	0.017
1,4-Dichlorobenzene	0.00024	Yes	1.96E-04	6.57E-05	3.63E-06	2.65E-04	0.0040
1,4-Dioxane	0.0078	--	1.45E-02	2.80E-05	--(b)	1.45E-02	0.22
Acetone	0.0013	Yes	8.20E-05	--	3.01E-07	8.21E-05	0.0012
Aluminum	0.022	--	1.27E-03	3.32E-06	--(b)	1.27E-03	0.019
Arsenic	0.0080	--	1.71E+00	4.46E-03	--(b)	1.71E+00	26
Barium	0.11	--	3.14E-02	1.17E-03	--(b)	3.26E-02	0.49
Boron	0.14	--	3.88E-02	1.01E-04	--(b)	3.90E-02	0.59
Bromomethane	0.00081	Yes	2.08E-02	3.18E-04	1.32E-03	2.22E-02	0.34
Chloride	37	--	--	--	--(b)	--	--
Chlorobenzene	0.00015	Yes	4.29E-04	7.71E-05	3.63E-05	5.42E-04	0.008
Chloroform	0.00048	Yes	2.80E-03	1.18E-04	3.61E-05	2.77E-03	0.042
Chloromethane	0.000077	Yes	--	--	3.03E-05	1.08E-05	0.00016
Chromium	0.026	--	1.00E-03	2.01E-04	--(b)	1.20E-03	0.018
Cobalt	0.00017	--	3.30E-02	1.64E-05	--(b)	3.30E-02	0.50
Copper	0.0023	--	3.33E-03	8.74E-06	--(b)	3.36E-03	0.051
Fluoride	0.52	--	4.95E-01	1.29E-03	--(b)	4.96E-01	7.5
Hexavalent Chromium	0.020	--	3.82E-01	7.97E-02	--(b)	4.62E-01	7.0
Iron	0.083	--	6.73E-03	1.76E-05	--(b)	6.75E-03	0.10
Lead	0.00020	--	--	--	--(b)	--	--
Lithium	0.083	--	1.00E+00	2.61E-03	--(b)	1.00E+00	15
Manganese	0.0050	--	1.43E-02	9.32E-04	--(b)	1.52E-02	0.23
Molybdenum	0.0078	--	9.08E-02	2.37E-04	--(b)	9.08E-02	1.4
Nickel	0.0050	--	1.43E-02	1.86E-04	--(b)	1.45E-02	0.22
Nitrate	110	--	8.81E-01	2.29E-03	--(b)	8.84E-01	13
Selenium	0.0042	--	4.81E-02	1.25E-04	--(b)	4.82E-02	0.73
Strontium	0.88	--	8.85E-02	2.31E-04	--(b)	8.88E-02	1.3
Styrene	0.00014	Yes	3.88E-05	4.08E-06	1.03E-06	4.88E-05	0.00074
Sulfate	127	--	--	--	--(b)	--	--
Tetrachloroethene	0.00018	Yes	1.71E-03	5.11E-04	5.44E-05	2.28E-03	0.035
Tin	0.00010	--	9.52E-06	2.48E-08	--(b)	9.54E-06	0.00014
Toluene	0.000072	Yes	5.14E-05	8.98E-06	1.74E-07	6.05E-05	0.0009
Trichloroethene	0.011	Yes	1.28E+00	1.08E-01	6.68E-03	1.43E+00	22
Trichloromonofluoromethane	0.00011	Yes	2.10E-05	2.08E-06	1.08E-06	2.40E-05	0.00036
Vanadium	0.017	--	1.94E-01	5.07E-04	--(b)	1.95E-01	3.0
Xylenes (total)	0.00020	Yes	5.71E-05	1.88E-05	2.42E-05	9.98E-05	0.0015
Zinc	0.0080	--	1.14E-03	1.79E-06	--(b)	1.14E-03	0.017
Total HI			6.33E+00	2.04E-01	6.80E-02	6.60E+00	100

[a]Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b]Nonvolatile constituents are not considered in the inhalation of groundwater in the drinking water pathway

-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.

HI = hazard index.

HQ = hazard quotient.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of Yakama Nation Drinking Water Exposure Scenario Cancer Risk Results for Nonradioactive Analytes in Groundwater.							
Nonradioactive Analyte Name	90th Percentile Concentration in Groundwater C_w (mg/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
1,2-Dichloroethane	0.00010	Yes	5.73E-07	1.38E-08	3.14E-08	6.18E-07	0.066
1,4-Dichlorobenzene	0.00024	Yes	8.16E-08	2.88E-08	3.19E-08	1.40E-07	0.015
1,4-Dioxane	0.0078	--	4.78E-05	8.45E-08	--(b)	4.79E-05	5.1
Acetone	0.0013	Yes	--	--	--	--	--
Aluminum	0.022	--	--	--	--(b)	--	--
Arsenic	0.0080	--	8.48E-04	2.24E-06	--(b)	8.48E-04	91
Barium	0.11	--	--	--	--(b)	--	--
Boron	0.14	--	--	--	--(b)	--	--
Bromomethane	0.00081	Yes	--	--	--	--	--
Chloride	37	--	--	--	--(b)	--	--
Chlorobenzene	0.00015	Yes	--	--	--	--	--
Chloroform	0.00048	Yes	8.88E-07	3.98E-08	1.28E-07	1.05E-06	0.11
Chloromethane	0.000077	Yes	--	--	--	--	--
Chromium	0.020	--	--	--	--(b)	--	--
Cobalt	0.00057	--	--	--	--(b)	--	--
Copper	0.0023	--	--	--	--(b)	--	--
Fluoride	0.52	--	--	--	--(b)	--	--
Hexavalent Chromium	0.020	--	--	--	--(b)	--	--
Iron	0.042	--	--	--	--(b)	--	--
Lead	0.00020	--	--	--	--(b)	--	--
Lithium	0.085	--	--	--	--(b)	--	--
Manganese	0.0080	--	--	--	--(b)	--	--
Molybdenum	0.0079	--	--	--	--(b)	--	--
Nickel	0.0080	--	--	--	--(b)	--	--
Nitrate	110	--	--	--	--(b)	--	--
Selenium	0.0042	--	--	--	--(b)	--	--
Strontium	0.94	--	--	--	--(b)	--	--
Styrene	0.00014	Yes	--	--	--	--	--
Sulfate	127	--	--	--	--(b)	--	--
Tetrachloroethene	0.00018	Yes	2.38E-08	6.98E-09	5.88E-10	3.13E-08	0.0034
Tin	0.00010	--	--	--	--(b)	--	--
Toluene	0.000072	Yes	--	--	--	--	--
Trichloroethene	0.011	Yes	3.18E-05	2.71E-06	5.45E-07	3.51E-05	3.8
Trichloromonofluoromethane	0.00011	Yes	--	--	--	--	--
Vanadium	0.017	--	--	--	--(b)	--	--
Xylenes (total)	0.00020	Yes	--	--	--	--	--
Zinc	0.0080	--	--	--	--(b)	--	--
Total ELCR			9.27E-04	5.12E-06	7.35E-07	9.33E-04	100

[a]Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b]Nonvolatile constituents are not considered in the inhalation of groundwater in the drinking water pathway

-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of Yakama Nation Drinking Water Exposure Scenario Cancer Risk Results for Radioactive Analytes in Groundwater.							
Radioactive Analyte Name	90th Percentile Concentration in Groundwater C_w (pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
Americium-241	0.13	--	1.32E-06	--	--(b)	1.32E-06	2.7
Carbon-14	12	--	1.80E-06	--	--(b)	1.80E-06	3.6
Gross alpha	6.2	--	--	--	--(b)	--	--
Plutonium-238	0.24	--	3.01E-06	--	--(b)	3.01E-06	6.1
Plutonium-239/240	0.70	--	9.21E-06	--	--(b)	9.21E-06	19
Strontium-90	3.3	--	1.80E-05	--	--(b)	1.80E-05	36
Technetium-99	6.1	--	1.64E-06	--	--(b)	1.64E-06	3.3
Tritium	2,700	Yes	1.34E-05	--	1.25E-06	1.46E-05	29
Total ELCR			4.84E-05	--	1.25E-06	4.97E-05	100

[a]Volatile radioactive contaminants as defined by EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

[b]Nonvolatile constituents are not considered in the inhalation of groundwater in the drinking water pathway

-- = indicates radionuclide toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of Yakama Nation Drinking Water Exposure Scenario Cancer Risk Results for Radioactive and Nonradioactive Analytes in Groundwater.							
Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
1,2-Dichloroethane	0.00010	Yes	5.73E-07	1.38E-08	3.14E-08	6.18E-07	0.063
1,4-Dichlorobenzene	0.00024	Yes	8.18E-08	2.88E-08	3.19E-08	1.40E-07	0.014
1,4-Dioxane	0.0078	--	4.78E-05	8.45E-08	--(b)	4.79E-05	4.9
Acetone	0.0013	Yes	--	--	--	--	--
Aluminum	0.022	--	--	--	--(b)	--	--
Arsenic	0.0050	--	8.48E-04	2.24E-06	--(b)	8.48E-04	86
Barium	0.11	--	--	--	--(b)	--	--
Boron	0.14	--	--	--	--(b)	--	--
Bromomethane	0.00081	Yes	--	--	--	--	--
Chloride	37	--	--	--	--(b)	--	--
Chlorobenzene	0.00015	Yes	--	--	--	--	--
Chloroform	0.00048	Yes	8.88E-07	3.98E-08	1.28E-07	1.06E-06	0.11
Chloromethane	0.000077	Yes	--	--	--	--	--
Chromium	0.026	--	--	--	--(b)	--	--
Cobalt	0.00017	--	--	--	--(b)	--	--
Copper	0.0023	--	--	--	--(b)	--	--
Fluoride	0.52	--	--	--	--(b)	--	--
Hexavalent Chromium	0.020	--	--	--	--(b)	--	--
Iron	0.083	--	--	--	--(b)	--	--
Lead	0.00020	--	--	--	--(b)	--	--
Lithium	0.083	--	--	--	--(b)	--	--
Manganese	0.0050	--	--	--	--(b)	--	--
Molybdenum	0.0078	--	--	--	--(b)	--	--
Nickel	0.0050	--	--	--	--(b)	--	--
Nitrate	110	--	--	--	--(b)	--	--
Selenium	0.0042	--	--	--	--(b)	--	--
Strontium	0.88	--	--	--	--(b)	--	--
Styrene	0.00014	Yes	--	--	--	--	--
Sulfate	127	--	--	--	--(b)	--	--
Tetrachloroethene	0.00018	Yes	2.38E-08	6.88E-09	5.88E-10	3.13E-08	0.0031
Tin	0.00010	--	--	--	--(b)	--	--
Toluene	0.000077	Yes	--	--	--	--	--
Trichloroethene	0.011	Yes	3.18E-05	2.71E-06	5.45E-07	3.51E-05	3.6
Trichloromonofluoromethane	0.00011	Yes	--	--	--	--	--
Vanadium	0.017	--	--	--	--(b)	--	--
Xylenes (total)	0.00020	Yes	--	--	--	--	--
Zinc	0.0080	--	--	--	--(b)	--	--
Americium-241	0.13	--	1.32E-06	--	--(b)	1.32E-06	0.13
Carbon-14	12	--	1.80E-06	--	--(b)	1.80E-06	0.18
Gross alpha	6.2	--	--	--	--(b)	--	--
Plutonium-238	0.24	--	3.01E-06	--	--(b)	3.01E-06	0.31
Plutonium-239/240	0.70	--	9.21E-06	--	--(b)	9.21E-06	0.94
Strontium-90	3.3	--	1.80E-05	--	--(b)	1.20E-05	1.8
Technetium-99	6.1	--	1.64E-06	--	--(b)	1.64E-06	0.17
Tritium	2,700	Yes	1.34E-05	--	1.25E-06	1.46E-05	1.5
Total Cumulative ELCR			9.75E-04	5.12E-06	1.98E-06	9.83E-04	100

[a] Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites" or as defined by EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity,"

[b] Nonvolatile constituents are not considered in the inhalation exposure route.

[c]-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

Attachment Table B-2. Ingestion of Nonradioactive Analytes in Drinking Water - Yakama Nation
100-FR-3 Groundwater Operable Unit Native American Risk Assessment

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Chronic Daily Intake - nonradiological ingestion	CDI	Calculated Value	mg/kg-day	Equations 5 and 8
Contaminant concentration in groundwater	C_w	Analyte-specific	mg/L	ECF-100FR3-11-0024
Body Weight - adult	BW_a	70	kg	Ridolfi, 2007
Body Weight - child	BW_c	16	kg	Ridolfi, 2007
Water Ingestion Rate - adult	IRW_a	4	L/day	Ridolfi, 2007
Water Ingestion Rate - child	IRW_c	2	L/day	Ridolfi, 2007
Age-Adjusted Water Ingestion Rate - nonradiological	IRW_{adj}	4.407	L-year/kg-day	Equation 6
Exposure Frequency	EF	365	days/year	Ridolfi, 2007
Exposure Duration - adult	ED_a	70	years	Ridolfi, 2007
Exposure Duration - child	ED_c	6	years	Ridolfi, 2007
Averaging time - carcinogens and noncarcinogens	AT	70	years	Ridolfi, 2007
Reference Dose - Oral	RfD_o	Analyte-specific	mg/kg-day	EPA, 2012
Cancer Slope Factor - Oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	EPA, 2012
Conversion Factor	CF1	365	days/year	1 year = 365 days

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment* .

EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	C_w (mg/L)	CDI (noncarcinogen) (mg/kg-day)	RfD_o* (mg/kg-day)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	0.00010	5.71E-08	6.00E-03	9.52E-04	0.015
1,4-Dichlorobenzene	106-46-7	0.00024	1.37E-03	7.00E-02	1.96E-04	0.0091
1,4-Dioxane	123-91-1	0.0076	4.34E-04	3.00E-02	1.45E-02	0.23
Acetone	67-64-1	0.0013	7.34E-05	9.00E-01	8.16E-03	0.0013
Aluminum	7429-90-5	0.022	1.27E-03	1.00E+00	1.27E-03	0.020
Arsenic	7440-38-2	0.0090	5.12E-04	3.00E-04	1.71E+00	27
Barium	7440-39-3	0.11	6.29E-03	2.00E-01	3.14E-02	0.50
Boron	7440-42-8	0.14	7.77E-03	2.00E-01	3.89E-02	0.61
Bromomethane	74-83-9	0.00051	2.89E-05	1.40E-03	2.06E-02	0.33
Chloride	16887-00-6	37	2.09E+00	--	--	--
Chlorobenzene	108-90-7	0.00015	8.57E-06	2.00E-02	4.29E-04	0.0068
Chloroform	67-66-3	0.00046	2.60E-05	1.00E-02	2.60E-03	0.041
Chloromethane	74-87-3	0.000077	4.40E-06	--	--	--
Chromium	7440-47-3	0.026	1.50E-03	1.50E+00	1.00E-03	0.016
Cobalt	7440-48-4	0.00017	9.89E-06	3.00E-04	3.30E-02	0.52
Copper	7440-50-8	0.0023	1.34E-04	4.00E-02	3.35E-03	0.053
Fluoride	16984-48-8	0.52	2.97E-02	8.00E-02	4.95E-01	7.8
Hexavalent Chromium	18540-29-9	0.020	1.15E-03	3.00E-03	3.82E-01	6.0
Iron	7439-89-6	0.083	4.71E-03	7.00E-01	6.73E-03	0.11
Lead	7439-92-1	0.00020	1.14E-05	--	--	--
Lithium	7439-93-2	0.035	2.00E-03	2.00E-03	1.00E+00	16
Manganese	7439-96-5	0.0060	3.43E-04	2.40E-02	1.43E-02	0.23
Molybdenum	7439-98-7	0.0079	4.51E-04	5.00E-03	9.06E-02	1.4
Nickel	7440-02-0	0.0050	2.86E-04	2.00E-02	1.43E-02	0.23
Nitrate	14797-55-8	110	6.26E+00	7.10E+00	8.81E-01	14
Selenium	7782-49-2	0.0042	2.40E-04	5.00E-03	4.81E-02	0.76
Strontium	7440-24-6	0.89	5.91E-02	6.00E-01	8.85E-02	1.4
Styrene	100-42-5	0.00014	7.71E-06	2.00E-01	3.86E-05	0.00061
Sulfate	14808-79-8	127	7.26E+00	--	--	--
Tetrachloroethene	127-18-4	0.00018	1.03E-05	6.00E-03	1.71E-03	0.027
Tin	7440-31-5	0.00010	5.71E-06	6.00E-01	9.52E-06	0.00015
Toluene	108-88-3	0.000072	4.11E-06	8.00E-02	5.14E-05	0.0008
Trichloroethene	79-01-6	0.011	6.29E-04	5.00E-04	1.26E+00	20
Trichloromonofluoromethane	75-69-4	0.00011	6.29E-06	3.00E-01	2.10E-05	0.00033
Vanadium	7440-62-2	0.017	9.71E-06	5.00E-03	1.94E-01	3.1
Xylenes (total)	1330-20-7	0.00020	1.14E-05	2.00E-01	5.71E-05	0.0009
Zinc	7440-66-6	0.0060	3.43E-04	3.00E-01	1.14E-03	0.018
Total HI					6.35E+00	100

*EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

-- = Indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.

HI = hazard index.

HQ = hazard quotient.

EPA 540/1-89/002 *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A).*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	C_w (mg/L)	CDI (carcinogen) (mg/kg-day)	CSF_o* $(mg/kg\text{-}day)^{-1}$	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	0.00010	6.30E-06	9.10E-02	5.73E-07	0.062
1,4-Dichlorobenzene	106-46-7	0.00024	1.51E-05	5.40E-03	8.16E-08	0.0088
1,4-Dioxane	123-91-1	0.0076	4.78E-04	1.00E-01	4.78E-05	5.2
Acetone	67-64-1	0.0013	8.09E-05	--	--	--
Aluminum	7429-90-5	0.022	1.40E-03	--	--	--
Arsenic	7440-38-2	0.0090	5.64E-04	1.50E+00	8.46E-04	91
Barium	7440-39-3	0.11	6.93E-03	--	--	--
Boron	7440-42-8	0.14	8.56E-03	--	--	--
Bromomethane	74-83-9	0.00051	3.18E-05	--	--	--
Chloride	16887-00-6	37	2.30E+00	--	--	--
Chlorobenzene	108-90-7	0.00015	9.44E-06	--	--	--
Chloroform	67-66-3	0.00046	2.86E-05	3.10E-02	8.88E-07	0.096
Chloromethane	74-87-3	0.000077	4.85E-06	--	--	--
Chromium	7440-47-3	0.026	1.65E-03	--	--	--
Cobalt	7440-48-4	0.00017	1.09E-05	--	--	--
Copper	7440-50-8	0.0023	1.48E-04	--	--	--
Fluoride	16984-48-8	0.52	3.27E-02	--	--	--
Hexavalent Chromium	18540-29-9	0.020	1.26E-03	--	--	--
Iron	7439-89-6	0.083	5.19E-05	--	--	--
Lead	7439-92-1	0.00020	1.26E-05	--	--	--
Lithium	7439-93-2	0.035	2.20E-03	--	--	--
Manganese	7439-96-5	0.0060	3.78E-04	--	--	--
Molybdenum	7439-98-7	0.0079	4.99E-04	--	--	--
Nickel	7440-02-0	0.0050	3.15E-04	--	--	--
Nitrate	14797-55-8	110	6.89E+00	--	--	--
Selenium	7782-49-2	0.0042	2.65E-04	--	--	--
Strontium	7440-24-6	0.89	5.85E-02	--	--	--
Styrene	100-42-5	0.00014	8.50E-06	--	--	--
Sulfate	14808-79-8	127	8.00E+00	--	--	--
Tetrachloroethene	127-18-4	0.00018	1.13E-05	2.10E-03	2.38E-08	0.0026
Tin	7440-31-5	0.00010	6.30E-06	--	--	--
Toluene	108-88-3	0.000072	4.53E-06	--	--	--
Trichloroethene	79-01-6	0.011	6.93E-04	4.60E-02	3.19E-05	3.4
Trichloromonofluoromethane	75-69-4	0.00011	6.93E-06	--	--	--
Vanadium	7440-62-2	0.017	1.07E-05	--	--	--
Xylenes (total)	1330-20-7	0.00020	1.26E-05	--	--	--
Zinc	7440-66-6	0.0060	3.78E-04	--	--	--
Total ELCR					9.27E-04	100

*EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

-- = Indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

EPA 540/1-89/002 *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A).*

Attachment Table B-3. Inhalation of Volatile Nonradioactive Analytes in Drinking Water - Yakama Nation
100-FR-3 Groundwater Operable Unit Native American Risk Assessment

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Chronic Daily Intake - nonradiological inhalation	CDI	Calculated Value	mg/m^3 for noncarcinogens, $\mu g/m^3$ for carcinogens	Equations 13 and 15
Contaminant concentration in groundwater	C_w	Analyte-specific	mg/L	ECF-100FR3-11-0024
Exposure Time- adult	ET_a	0.58	hours/day	EPA/540/R/99/005
Exposure Frequency	EF	365	days/year	Ridolfi, 2007
Exposure Duration - adult	ED_a	70	years	Ridolfi, 2007
Averaging time - carcinogens and noncarcinogens	AT	70	years	Ridolfi, 2007
Volatilization Factor	VF	0.5	L/m^3	EPA/540/R-92/003
Reference Concentration	RfC_i	Analyte-specific	mg/m^3	EPA, 2012
Inhalation Unit Risk	IUR	Analyte-specific	$(\mu g/m^3)^{-1}$	EPA, 2012
Conversion Factor	CF1	365	days/year	1 year = 365 days
Conversion Factor	CF2	1/24	days/hour	1 day = 24 hours

Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment.*

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim.*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[2]	C_w (mg/L)	CDI (noncarcinogen) (mg/m^3)	RfC[1] (mg/m^3)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	1.21E-06	7.00E-03	1.73E-04	0.25
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	2.90E-06	8.00E-01	3.63E-06	0.0053
1,4-Dioxane	123-91-1	--	0.0076	--(b)	3.00E+00	--(b)	--
Acetone	67-64-1	Yes	0.0013	1.55E-05	3.10E+01	5.01E-07	0.00074
Aluminum	7429-90-5	--	0.022	--(b)	5.00E-03	--(b)	--
Arsenic	7440-38-2	--	0.0080	--(b)	1.50E-03	--(b)	--
Barium	7440-39-3	--	0.11	--(b)	5.00E-04	--(b)	--
Boron	7440-42-8	--	0.14	--(b)	2.00E-02	--(b)	--
Bromomethane	74-83-9	Yes	0.00051	6.10E-06	5.00E-03	1.22E-05	1.8
Chloride	16887-00-6	--	37	--(b)	--	--(b)	--
Chlorobenzene	108-90-7	Yes	0.00015	1.81E-06	5.00E-02	3.62E-05	0.053
Chloroform	67-66-3	Yes	0.00046	5.50E-06	9.80E-02	5.61E-05	0.082
Chloromethane	74-87-3	Yes	0.000077	9.30E-07	9.00E-02	1.03E-05	0.015
Chromium	7440-47-3	--	0.026	--(b)	--	--(b)	--
Cobalt	7440-48-4	--	0.00017	--(b)	6.00E-06	--(b)	--
Copper	7440-50-8	--	0.0023	--(b)	--	--(b)	--
Fluoride	16984-48-8	--	0.52	--(b)	1.30E-02	--(b)	--
Hexavalent Chromium	18540-29-9	--	0.020	--(b)	1.00E-04	--(b)	--
Iron	7439-89-6	--	0.083	--(b)	--	--(b)	--
Lead	7439-92-1	--	0.00020	--(b)	--	--(b)	--
Lithium	7439-93-2	--	0.085	--(b)	--	--(b)	--
Manganese	7439-96-5	--	0.0080	--(b)	5.00E-05	--(b)	--
Molybdenum	7439-98-7	--	0.0079	--(b)	--	--(b)	--
Nickel	7440-02-0	--	0.0050	--(b)	9.00E-03	--(b)	--
Nitrate	14797-55-8	--	110	--(b)	--	--(b)	--
Selenium	7782-49-2	--	0.0042	--(b)	2.00E-02	--(b)	--
Strontium	7440-24-6	--	0.83	--(b)	--	--(b)	--
Styrene	100-42-5	Yes	0.00014	1.63E-06	1.00E+00	1.63E-06	0.0024
Sulfate	14808-79-8	--	127	--(b)	--	--(b)	--
Tetrachloroethene	127-18-4	Yes	0.00018	2.13E-06	4.00E-02	5.44E-05	0.080
Tin	7440-31-5	--	0.00010	--(b)	--	--(b)	--
Toluene	108-88-3	Yes	0.000072	8.70E-07	5.00E+00	1.74E-07	0.00026
Trichloroethene	79-01-6	Yes	0.011	1.33E-04	2.00E-03	6.65E-02	98
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.33E-06	7.00E-01	1.90E-06	0.0028
Vanadium	7440-62-2	--	0.017	--(b)	--	--(b)	--
Xylenes (total)	1330-20-7	Yes	0.00020	2.42E-06	1.00E-01	2.42E-05	0.036
Zinc	7440-66-6	--	0.0060	--(b)	--	--(b)	--
Total HI						6.80E-02	100

[1]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[2]Nonvolatile constituents are not considered in the inhalation of groundwater in the drinking water pathway

-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.

HI = hazard index.

HQ = hazard quotient.

EPA-540-R-070-002, *Risk Assessment Guidance for Superfund: Volume 1—Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[2]	C_w (mg/L)	CDI (cancer) $\mu g/m^3$	IUR[1] $(\mu g/m^3)^{-1}$	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	1.21E-03	2.60E-05	3.14E-08	4.3
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	2.90E-03	1.10E-05	3.19E-08	4.3
1,4-Dioxane	123-91-1	--	0.0076	--(b)	7.70E-08	--(b)	--
Acetone	67-64-1	Yes	0.0013	1.55E-02	--	--	--
Aluminum	7429-90-5	--	0.022	--(b)	--	--(b)	--
Arsenic	7440-38-2	--	0.0080	--(b)	4.30E-03	--(b)	--
Barium	7440-39-3	--	0.11	--(b)	--	--(b)	--
Boron	7440-42-8	--	0.14	--(b)	--	--(b)	--
Bromomethane	74-83-9	Yes	0.00051	6.10E-03	--	--	--
Chloride	16887-00-6	--	37	--(b)	--	--(b)	--
Chlorobenzene	108-90-7	Yes	0.00015	1.81E-03	--	--	--
Chloroform	67-66-3	Yes	0.00046	5.50E-03	2.30E-05	1.26E-07	17
Chloromethane	74-87-3	Yes	0.000077	9.30E-04	--	--	--
Chromium	7440-47-3	--	0.026	--(b)	--	--(b)	--
Cobalt	7440-48-4	--	0.00017	--(b)	9.00E-03	--(b)	--
Copper	7440-50-8	--	0.0023	--(b)	--	--(b)	--
Fluoride	16984-48-8	--	0.52	--(b)	--	--(b)	--
Hexavalent Chromium	18540-29-9	--	0.020	--(b)	8.40E-02	--(b)	--
Iron	7439-89-6	--	0.083	--(b)	--	--(b)	--
Lead	7439-92-1	--	0.00020	--(b)	--	--(b)	--
Lithium	7439-93-2	--	0.085	--(b)	--	--(b)	--
Manganese	7439-96-5	--	0.0080	--(b)	--	--(b)	--
Molybdenum	7439-98-7	--	0.0079	--(b)	--	--(b)	--
Nickel	7440-02-0	--	0.0050	--(b)	2.60E-04	--(b)	--
Nitrate	14797-55-8	--	110	--(b)	--	--(b)	--
Selenium	7782-49-2	--	0.0042	--(b)	--	--(b)	--
Strontium	7440-24-6	--	0.83	--(b)	--	--(b)	--
Styrene	100-42-5	Yes	0.00014	1.63E-03	--	--	--
Sulfate	14808-79-8	--	127	--(b)	--	--(b)	--
Tetrachloroethene	127-18-4	Yes	0.00018	2.13E-03	2.90E-07	5.66E-10	0.077
Tin	7440-31-5	--	0.00010	--(b)	--	--(b)	--
Toluene	108-88-3	Yes	0.000072	8.70E-04	--	--	--
Trichloroethene	79-01-6	Yes	0.011	1.33E-01	4.10E-06	5.45E-07	74
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.33E-03	--	--	--
Vanadium	7440-62-2	--	0.017	--(b)	--	--(b)	--
Xylenes (total)	1330-20-7	Yes	0.00020	2.42E-03	--	--	--
Zinc	7440-66-6	--	0.0080	--(b)	--	--(b)	--
Total ELCR						7.35E-07	100

[1]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[2]Nonvolatile constituents are not considered in the inhalation of groundwater in the drinking water pathway

-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

EPA-540-R-070-002, *Risk Assessment Guidance for Superfund: Volume 1—Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).*

Attachment Table B-4. Dermal Absorption of Nonradioactive Analytes in Drinking Water - Yakama Nation
100-FR-3 Groundwater Operable Unit Native American Risk Assessment

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Chronic Daily Intake - Dermal	CDI	calculated	mg/kg-day	Equations 22 and 24
Contaminant concentration in groundwater	C_w	Analyte-specific	mg/L	ECF-100FR3-11-0024
Body Weight - adult	BW_a	70	kg	Ridolfi, 2007
Body Weight - child	BW_c	16	kg	Ridolfi, 2007
Exposure Time - adult	ET_a	0.58	hours/event	EPA/540/R/99/005
Exposure Time - child	ET_c	1	hours/event	EPA/540/R/99/005
Age-Adjusted Exposure Time	ET_{adj}	0.626	hours/event	Equation 26
Skin Surface Area - adult	SA_a	18,000	cm^2	EPA/540/R/99/005
Skin Surface Area - child	SA_c	6,600	cm^2	EPA/540/R/99/005
Age-Adjusted Skin Surface Area	SA_{adj}	[illegible]	(cm2-year-event)/(kg-day)	Equation 23
Event Frequency - adult	EV_a	1	event/day	EPA/540/R/99/005
Event Frequency - child	EV_c	1	event/day	EPA/540/R/99/005
Exposure Frequency	EF	365	days/year	Ridolfi, 2007
Exposure Duration - adult	ED_a	70	years	Ridolfi, 2007
Exposure Duration - child	ED_c	6	years	Ridolfi, 2007
Averaging time - carcinogens and noncarcinogens	AT	70	years	Ridolfi, 2007
Reference Dose - Oral	RfD_o	Analyte-specific	mg/kg-day	EPA, 2012
Cancer Slope Factor - Oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	EPA, 2012
Gastrointestinal absorption factor	GIABS	Analyte-specific	unitless	EPA, 2012
Conversion Factor	CF1	365	days/year	1 year = 365 days
Conversion Factor	CF2	0.001	L/cm^3	$1 L = 1000 cm^3$
The constant pi	π	3.14159	unitless	--
Time to reach steady-state conditions	t^*	Analyte-specific	hours	EPA/540/R/99/005
Partitioning constant derived by Bunge Model	B	Analyte-specific	unitless	EPA/540/R/99/005
Absorbed Dose per Event	DA_{event}	Calculated Value	$(mg/cm^2\text{-}event)$	Equations 27, 28, and 29
Dermal Permeability Coefficient	K_p	Analyte-specific	cm/hour	EPA/540/R/99/005
Fraction of absorbed water	FA	Analyte-specific	unitless	EPA/540/R/99/005
Lag Time	τ	Analyte-specific	hours/event	EPA/540/R/99/005

Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment.*
ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*
EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). Interim.*
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final.*
EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

Absorbed Dermal Dose Calculation

100-FR-3 Operable Unit Exposure Area Native American Risk Assessment - Dermal Absorbed Dose Calculations										
Nonradioactive Analyte Name	CAS #	C_w (mg/L)	Inorganic/organic[1]	FA[2] (unitless)	K_p[2] (cm/hour)	B[2] (unitless)	τ[2] (hours/event)	t^*[2] (hours)	DA (noncancer) $(mg/cm^2\text{-}event)$	DA (cancer) $(mg/cm^2\text{-}event)$
1,2-Dichloroethane	107-06-2	[illegible]	--	1	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
1,4-Dichlorobenzene	106-46-7	[illegible]	--	1	[illegible]	0.1	0.71	1.71	[illegible]	[illegible]
1,4-Dioxane	123-91-1	0.0076	--	1	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
Acetone[3]	67-64-1	[illegible]	--	--	[illegible]	--	--	--	--	--
Aluminum	7429-90-5	0.011	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Arsenic	7440-38-2	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Barium	7440-39-3	0.11	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Boron	7440-42-8	0.16	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Bromomethane	74-83-9	[illegible]	--	1	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
Chloride	16887-00-6	37	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Chlorobenzene	108-90-7	[illegible]	--	1	[illegible]	0.1	[illegible]	[illegible]	[illegible]	[illegible]
Chloroform	67-66-3	[illegible]	--	1	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
Chloromethane	74-87-3	[illegible]	--	1	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
Chromium	7440-47-3	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Cobalt	7440-48-4	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Copper	7440-50-8	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Fluoride	16984-48-8	0.52	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Hexavalent Chromium	18540-29-9	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Iron	7439-89-6	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Lead	7439-92-1	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Lithium	7439-93-2	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Manganese	7439-96-5	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Molybdenum	7439-98-7	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Nickel	7440-02-0	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Nitrate	14797-55-8	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Selenium	7782-49-2	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Strontium	7440-24-6	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Styrene	100-42-5	[illegible]	--	1	[illegible]	0.1	[illegible]	[illegible]	[illegible]	[illegible]
Sulfate	14808-79-8	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Tetrachloroethene	127-18-4	[illegible]	--	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tin	7440-31-5	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Toluene	108-88-3	[illegible]	--	1	[illegible]	0.1	[illegible]	[illegible]	[illegible]	[illegible]
Trichloroethene	79-01-6	[illegible]	--	1	[illegible]	0.1	[illegible]	[illegible]	[illegible]	[illegible]
Trichloromonofluoromethane	75-69-4	[illegible]	--	1	[illegible]	0.1	[illegible]	[illegible]	[illegible]	[illegible]
Vanadium	7440-62-2	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]
Xylenes (total)	1330-20-7	[illegible]	--	1	[illegible]	0.2	[illegible]	[illegible]	[illegible]	[illegible]
Zinc	7440-66-6	[illegible]	INORGANIC	--	[illegible]	--	--	--	[illegible]	[illegible]

[1] EPA/540/R/99/005 Exhibit B-3 (inorganics) and Exhibit B-1
[2] EPA/540/R/99/005 Exhibit B-3
[3] The K_p value was taken from [illegible]
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final.*

Noncancer HQ calculation

Nonradioactive Analyte Name	CAS #	C_w (mg/L)	CDI (noncarcinogen) (mg/kg-day)	RfD_o[a] (mg/kg-day)	GIABS[a] (unitless)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1,4-Dichlorobenzene	106-46-7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1,4-Dioxane	123-91-1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Acetone	67-64-1	[illegible]	--	[illegible]	[illegible]	--	--
Aluminum	7429-90-5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Arsenic	7440-38-2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Barium	7440-39-3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Boron	7440-42-8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bromomethane	74-83-9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chloride	16887-00-6	37	[illegible]	--	--	--	--
Chlorobenzene	108-90-7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chloroform	67-66-3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chloromethane	74-87-3	[illegible]	[illegible]	--	[illegible]	--	--
Chromium	7440-47-3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cobalt	7440-48-4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Copper	7440-50-8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fluoride	16984-48-8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hexavalent Chromium	18540-29-9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Iron	7439-89-6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lead	7439-92-1	[illegible]	[illegible]	--	[illegible]	--	--
Lithium	7439-93-2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Manganese	7439-96-5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Molybdenum	7439-98-7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nickel	7440-02-0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nitrate	14797-55-8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Selenium	7782-49-2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Strontium	7440-24-6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Styrene	100-42-5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sulfate	14808-79-8	[illegible]	[illegible]	--	--	--	--
Tetrachloroethene	127-18-4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tin	7440-31-5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Toluene	108-88-3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trichloroethene	79-01-6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trichloromonofluoromethane	75-69-4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Vanadium	7440-62-2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Xylenes (total)	1330-20-7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Zinc	7440-66-6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total HI						[illegible]	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.
HI = hazard index.
HQ = hazard quotient.
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final.*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	C_w (mg/L)	CDI (carcinogen) (mg/kg-day)	CSF_o[a] $(mg/kg\text{-}day)^{-1}$	GIABS[a] (unitless)	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1,4-Dichlorobenzene	106-46-7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1,4-Dioxane	123-91-1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Acetone	67-64-1	[illegible]	--	--	[illegible]	--	--
Aluminum	7429-90-5	[illegible]	[illegible]	--	[illegible]	--	--
Arsenic	7440-38-2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Barium	7440-39-3	[illegible]	[illegible]	--	[illegible]	--	--
Boron	7440-42-8	[illegible]	[illegible]	--	[illegible]	--	--
Bromomethane	74-83-9	[illegible]	[illegible]	--	[illegible]	--	--
Chloride	16887-00-6	37	[illegible]	--	--	--	--
Chlorobenzene	108-90-7	[illegible]	[illegible]	--	[illegible]	--	--
Chloroform	67-66-3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chloromethane	74-87-3	[illegible]	[illegible]	--	[illegible]	--	--
Chromium	7440-47-3	[illegible]	[illegible]	--	[illegible]	--	--
Cobalt	7440-48-4	[illegible]	[illegible]	--	[illegible]	--	--
Copper	7440-50-8	[illegible]	[illegible]	--	[illegible]	--	--
Fluoride	16984-48-8	[illegible]	[illegible]	--	[illegible]	--	--
Hexavalent Chromium	18540-29-9	[illegible]	[illegible]	--	[illegible]	--	--
Iron	7439-89-6	[illegible]	[illegible]	--	[illegible]	--	--
Lead	7439-92-1	[illegible]	[illegible]	--	[illegible]	--	--
Lithium	7439-93-2	[illegible]	[illegible]	--	[illegible]	--	--
Manganese	7439-96-5	[illegible]	[illegible]	--	[illegible]	--	--
Molybdenum	7439-98-7	[illegible]	[illegible]	--	[illegible]	--	--
Nickel	7440-02-0	[illegible]	[illegible]	--	[illegible]	--	--
Nitrate	14797-55-8	[illegible]	[illegible]	--	[illegible]	--	--
Selenium	7782-49-2	[illegible]	[illegible]	--	[illegible]	--	--
Strontium	7440-24-6	[illegible]	[illegible]	--	[illegible]	--	--
Styrene	100-42-5	[illegible]	[illegible]	--	[illegible]	--	--
Sulfate	14808-79-8	[illegible]	[illegible]	--	--	--	--
Tetrachloroethene	127-18-4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tin	7440-31-5	[illegible]	[illegible]	--	[illegible]	--	--
Toluene	108-88-3	[illegible]	[illegible]	--	[illegible]	--	--
Trichloroethene	79-01-6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trichloromonofluoromethane	75-69-4	[illegible]	[illegible]	--	[illegible]	--	--
Vanadium	7440-62-2	[illegible]	[illegible]	--	[illegible]	--	--
Xylenes (total)	1330-20-7	[illegible]	[illegible]	--	[illegible]	--	--
Zinc	7440-66-6	[illegible]	[illegible]	--	[illegible]	--	--
Total ELCR						[illegible]	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] Phosphorus should be identified as Phosphate, and therefore does not have applicable toxicity values.
-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final.*

Attachment Table B-5. Inhalation of Volatile Radioactive Analytes in Drinking Water - Yakama Nation
100-FR-3 Groundwater Operable Unit Native American Risk Assessment

Intake Parameter Values				
Factor	Symbol	Value	Unit	Reference
Chronic Daily Intake - radiological inhalation	CDI	Calculated Value	pCi	Equation 17
Contaminant concentration in groundwater	C_w	Analyte-specific	pCi/L	ECF-100FR3-11-0024
Exposure frequency	EF	365	days/year	Ridolfi, 2007
Exposure Duration - adult	ED_a	70	years	Ridolfi, 2007
Exposure Duration - child	ED_c	6	years	Ridolfi, 2007
Inhalation Rate - adult	INH_a	26	m^3/day	Ridolfi, 2007
Inhalation Rate - child	INH_c	16	m^3/day	Ridolfi, 2007
Age-adjusted Inhalation Rate - radiological	INH_RAD_{adj}	1760	m^3-year/day	Equations 18
Exposure Time - adult	ET_a	0.58	hoursr/day	EPA/540/R/99/005
Exposure Time - child	ET_c	1	hoursr/day	EPA/540/R/99/005
Age-Adjusted Exposure Time	ET_{adj}	0.616	hours/day	Equations 19
Conversion Factor	CF2	0.042	days/hour	1 day = 24 hours
Volatilization Factor	VF	0.5	L/m^3	EPA/540/R-92/003
Slope Factor - inhalation	SF_i	Analyte-specific	risk/pCi	EPA, 2001

Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment.*

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

Inhalation of Volatile Radioactive Constituents in Groundwater

Radioactive Analyte Name	CAS #	Volatile[a]	C_w (pCi/L)	CDI (radiological inhalation) (pCi)	SF_i (risk/pCi)	Risk (unitless)	% Contribution
Americium-241	14596-10-2	--	0.13	--(b)	2.81E-08	--(b)	--
Carbon-14	14762-75-5	--	12	--(b)	7.07E-12	--(b)	--
Gross alpha	12587-46-1	--	6.2	--(b)	--	--(b)	--
Plutonium-238	13981-16-3	--	0.24	--(b)	3.36E-08	--(b)	--
Plutonium-239/240	15117-48-3	--	0.70	--(b)	3.33E-08	--(b)	--
Strontium-90	10098-97-2	--	3.3	--(b)	1.05E-10	--(b)	--
Technetium-99	14133-76-7	--	6.1	--(b)	1.41E-11	--(b)	--
Tritium	10028-17-8	Yes	2,700	2.23E+07	5.62E-14	1.25E-06	100
Total ELCR						1.25E-06	100

[a]Volatile radioactive contaminants as defined by EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

[b]Nonvolatile constituents are not considered in the inhalation of groundwater in the drinking water pathway

ELCR = excess lifetime cancer risk.

EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final.*

Attachment Table B-6. Ingestion of Radioactive Analytes in Drinking Water - Yakama Nation 100-FR-3 Groundwater Operable Unit Native American Risk Assessment

Intake Parameter Values				
Factor	Symbol	Value	Unit	Reference
Chronic Daily Intake - radiological ingestion	CDI	Calculated Value	pCi	Equation 10
Contaminant concentration in groundwater	C_w	Analyte-specific	pCi/L	ECF-100FR3-11-0024
Exposure frequency	EF	365	days/year	Ridolfi, 2007
Exposure Duration - adult	ED_a	70	years	Ridolfi, 2007
Exposure Duration - child	ED_c	6	years	Ridolfi, 2007
Water Ingestion Rate - adult	IRW_a	4	L/day	Ridolfi, 2007
Water Ingestion Rate - child	IRW_c	2	L/day	Ridolfi, 2007
Age-adjusted water ingestion rate - radiological	IRW_RAD_{adj}	268	L-year/day	Equation 11
Slope Factor - oral	SF_o	Analyte-specific	risk/pCi	EPA, 2001

Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment.*

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals): Interim.*

EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

Ingestion of Radioactive Constituents in Groundwater

Radioactive Analyte Name	CAS #	C_w (pCi/L)	CDI (radiological ingestion) (pCi)	SF_o (risk/pCi)	Risk (unitless)	% Contribution
Americium-241	14596-10-2	0.13	1.27E+04	1.04E-10	1.32E-06	2.7
Carbon-14	14762-75-5	12	1.16E+06	1.55E-12	1.80E-06	3.7
Gross alpha	12587-46-1	6.2	6.02E+05	--	--	--
Plutonium-238	13981-16-3	0.24	2.30E+04	1.31E-10	3.01E-06	6.2
Plutonium-239/240	15117-48-3	0.70	6.82E+04	1.35E-10	9.21E-06	19
Strontium-90	10098-97-2	3.3	3.23E+05	5.59E-11	1.80E-05	37
Technetium-99	14133-76-7	6.1	5.97E+05	2.75E-12	1.64E-06	3.4
Tritium	10028-17-8	2,700	2.64E+08	5.07E-14	1.34E-05	28
Total ELCR					4.84E-05	100

ELCR = excess lifetime cancer risk.

EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final.*

ATTACHMENT C

Attachment Table C-1. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of CTUIR Sweat Lodge Exposure Scenario Noncancer Hazard Results for Radioactive and Nonradioactive Analytes in Groundwater.

Nonradioactive Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (mg/L)	Volatile[a]	HQ (Inhalation) (Volatiles and Semi-Volatiles)	HQ (Inhalation) (Nonvolatiles)	HQ (Dermal, Vapor, Volatiles and Semi-Volatiles)	HQ (Dermal, Liquid, Nonvolatiles)	HQ (Dermal, Vapor, Nonvolatiles)	Total HQ	% Contribution
1,2-Dichloroethane	0.00010	Yes	7.11E-04	–	1.72E-08	–	–	7.11E-04	0.0063
1,4-Dichlorobenzene	0.00024	Yes	1.49E-03	–	3.54E-08	–	–	1.50E-03	0.00013
1,4-Dioxane	0.0076	Yes[b]	1.26E-04	–	2.05E-08	–	–	1.26E-04	0.0011
Acetone	0.0013	Yes	1.08E-06	–	1.80E-10	–	–	2.08E-06	0.000018
Aluminum	0.021	–	–	3.80E-02	–	5.72E-06	8.17E-10	3.80E-02	0.34
Arsenic	0.0080	–	–	5.08E+00	–	7.60E-03	1.08E-05	5.10E+00	45
Barium	0.11	–	–	1.88E+00	–	2.02E-03	3.31E-07	1.88E+00	17
Boron	0.14	–	–	3.80E-02	–	1.75E-04	3.67E-09	3.82E-02	0.31
Bromomethane	0.00081	Yes	5.02E-03	–	2.48E-07	–	–	5.02E-03	0.044
Chloride	37	–	–	–	–	–	–	–	–
Chlorobenzene	0.00015	Yes	1.49E-04	–	3.96E-08	–	–	1.49E-04	0.0013
Chloroform	0.00048	Yes	2.31E-04	–	7.60E-08	–	–	2.31E-04	0.0020
Chloromethane	0.000077	Yes	4.26E-05	–	–	–	–	4.26E-05	0.00038
Chromium	0.026	–	–	–	–	3.46E-04	3.67E-09	3.46E-04	0.0031
Cobalt	0.00017	–	–	2.46E-01	–	3.98E-05	8.72E-09	2.46E-01	2.2
Copper	0.0023	–	–	–	–	1.31E-05	2.47E-09	1.31E-05	0.00012
Fluoride	0.52	–	–	3.41E-01	–	3.23E-04	8.63E-07	3.49E-01	3.0
Hexavalent Chromium	0.020	–	–	1.71E+00	–	1.17E-01	2.23E-05	1.83E+00	16
Iron	0.088	–	–	–	–	3.05E-05	4.97E-09	3.05E-05	0.00027
Lead	0.00020	–	–	–	–	–	–	–	–
Lithium	0.083	–	–	–	–	4.30E-03	7.87E-07	4.30E-03	0.040
Manganese	0.0080	–	–	1.02E+00	–	1.61E-03	2.68E-07	1.02E+00	9.1
Molybdenum	0.0079	–	–	–	–	4.08E-04	6.68E-08	4.08E-04	0.0036
Nickel	0.0080	–	–	4.74E-01	–	3.21E-04	5.27E-09	4.74E-01	4.2
Nitrate	110	–	–	–	–	3.97E-03	6.30E-07	3.97E-03	0.035
Selenium	0.0042	–	–	1.79E-03	–	2.18E-04	3.54E-08	2.01E-03	0.018
Strontium	0.88	–	–	–	–	3.80E-04	6.33E-08	3.80E-04	0.0035
Styrene	0.00014	Yes	6.71E-06	–	6.13E-09	–	–	6.72E-06	0.000059
Sulfate	127	–	–	–	–	–	–	–	–
Tetrachloroethene	0.00014	Yes	2.24E-04	–	1.48E-07	–	–	2.24E-04	0.0020
Tin	0.00041	–	–	–	–	4.29E-08	7.02E-12	4.29E-08	0.00000038
Toluene	0.000071	Yes	7.16E-07	–	6.65E-09	–	–	7.23E-07	0.0000064
Trichloroethene	0.011	Yes	2.74E-01	–	6.48E-05	–	–	2.74E-01	2.4
Trichloromonofluoromethane	0.00011	Yes	7.82E-06	–	1.17E-08	–	–	7.82E-06	0.000069
Vanadium	0.017	–	–	–	–	8.74E-04	1.48E-07	8.74E-04	0.0077
Xylenes (total)	0.00020	Yes	8.85E-05	–	1.30E-08	–	–	8.85E-05	0.00068
Zinc	0.0060	–	–	–	–	3.08E-06	5.06E-10	3.08E-06	0.000027
Total HI			2.80E-01	1.09E+01	6.55E-05	1.62E-01	2.66E-05	1.13E+01	100

[a] Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
– = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.
CTUIR = Confederated Tribes of the Umatilla Indian Reservation.
HI = hazard index.
HQ = hazard quotient.
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of CTUIR Sweat Lodge Exposure Scenario Cancer Risk Results for Nonradioactive Analytes in Groundwater.

Nonradioactive Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (mg/L)	Volatile[a]	Risk (Inhalation) (Volatiles and Semi-Volatiles)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, Volatiles and Semi-Volatiles)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
1,2-Dichloroethane	0.00010	Yes	1.26E-07	–	9.12E-12	–	–	1.26E-07	0.00088
1,4-Dichlorobenzene	0.00024	Yes	1.28E-07	–	1.90E-11	–	–	1.28E-07	0.00090
1,4-Dioxane	0.0076	Yes[b]	2.88E-06	–	5.86E-11	–	–	2.88E-06	0.020
Acetone	0.0013	Yes	–	–	–	–	–	–	–
Aluminum	0.021	–	–	–	–	–	–	–	–
Arsenic	0.0080	–	–	3.14E-04	–	3.36E-06	5.50E-10	3.23E-04	2.3
Barium	0.11	–	–	–	–	–	–	–	–
Boron	0.14	–	–	–	–	–	–	–	–
Bromomethane	0.00081	Yes	–	–	–	–	–	–	–
Chloride	37	–	–	–	–	–	–	–	–
Chlorobenzene	0.00015	Yes	–	–	–	–	–	–	–
Chloroform	0.00048	Yes	5.08E-07	–	2.23E-11	–	–	5.08E-07	0.0036
Chloromethane	0.000077	Yes	–	–	–	–	–	–	–
Chromium	0.026	–	–	–	–	–	–	–	–
Cobalt	0.00017	–	–	1.20E-05	–	–	–	1.20E-05	0.081
Copper	0.0023	–	–	–	–	–	–	–	–
Fluoride	0.52	–	–	–	–	–	–	–	–
Hexavalent Chromium	0.020	–	–	1.38E-02	–	–	–	1.38E-02	88
Iron	0.088	–	–	–	–	–	–	–	–
Lead	0.00020	–	–	–	–	–	–	–	–
Lithium	0.083	–	–	–	–	–	–	–	–
Manganese	0.0080	–	–	–	–	–	–	–	–
Molybdenum	0.0079	–	–	–	–	–	–	–	–
Nickel	0.0080	–	–	1.08E-05	–	–	–	1.08E-05	0.076
Nitrate	110	–	–	–	–	–	–	–	–
Selenium	0.0042	–	–	–	–	–	–	–	–
Strontium	0.88	–	–	–	–	–	–	–	–
Styrene	0.00014	Yes	–	–	–	–	–	–	–
Sulfate	127	–	–	–	–	–	–	–	–
Tetrachloroethene	0.00018	Yes	2.26E-08	–	2.80E-12	–	–	2.26E-08	0.00016
Tin	0.00010	–	–	–	–	–	–	–	–
Toluene	0.000072	Yes	–	–	–	–	–	–	–
Trichloroethene	0.011	Yes	2.18E-06	–	1.43E-08	–	–	2.18E-06	0.015
Trichloromonofluoromethane	0.00011	Yes	–	–	–	–	–	–	–
Vanadium	0.017	–	–	–	–	–	–	–	–
Xylenes (total)	0.00020	Yes	–	–	–	–	–	–	–
Zinc	0.0060	–	–	–	–	–	–	–	–
Total ELCR			5.77E-06	1.42E-02	1.56E-08	3.36E-06	5.50E-10	1.42E-02	100

[a] Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
– = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.
CTUIR = Confederated Tribes of the Umatilla Indian Reservation.

ELCR = excess lifetime cancer risk.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of CTUIR Sweat Lodge Exposure Scenario Cancer Risk Results for Radioactive Analytes in Groundwater.

Radioactive Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (pCi/L)	Volatile[a]	Risk (Inhalation) (Volatiles and Semi-Volatiles)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, Volatiles and Semi-Volatiles)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
Americium-241	0.13	–	–	1.55E-05	–	–	–	1.55E-05	10
Carbon-14	12	–	–	3.53E-07	–	–	–	3.53E-07	0.23
Gross alpha	6.3	–	–	–	–	–	–	–	–
Plutonium-238	0.24	–	–	3.34E-05	–	–	–	3.34E-05	22
Plutonium-239/240	0.70	–	–	9.84E-05	–	–	–	9.84E-05	64
Strontium-90	5.3	–	–	1.47E-06	–	–	–	1.47E-06	0.96
Technetium-99	6.1	–	–	3.63E-07	–	–	–	3.63E-07	0.24
Tritium	2,700	Yes	3.73E-06	–	–	–	–	3.73E-06	2.4
Total ELCR			3.73E-06	1.50E-04	–	–	–	1.53E-04	100

[a] Volatile radioactive contaminants as defined by EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."
– = indicates radionuclide toxicity criteria not available to quantify contaminant's cancer risk via this exposure route
CTUIR = Confederated Tribes of the Umatilla Indian Reservation.
ELCR = excess lifetime cancer risk.
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment–Summary of CTUIR Sweat Lodge Exposure Scenario Cancer Risk Results for Radioactive and Nonradioactive Analytes in Groundwater.

Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (mg/L or pCi/L)	Volatile[a]	Risk (Inhalation) (Volatiles and Semi-Volatiles)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, Volatiles and Semi-Volatiles)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
1,2-Dichloroethane	0.00010	Yes	1.26E-07	–	9.12E-12	–	–	1.26E-07	0.00087
1,4-Dichlorobenzene	0.00024	Yes	1.28E-07	–	1.30E-11	–	–	1.28E-07	0.00089
1,4-Dioxane	0.0076	Yes[b]	2.88E-06	–	5.86E-11	–	–	2.83E-06	0.020
Acetone	0.0013	Yes	–	–	–	–	–	–	–
Aluminum	0.022	–	–	–	–	–	–	–	–
Arsenic	0.0080	–	–	3.19E-04	–	3.36E-06	5.50E-10	3.23E-04	2.2
Barium	0.11	–	–	–	–	–	–	–	–
Boron	0.14	–	–	–	–	–	–	–	–
Bromomethane	0.00081	Yes	–	–	–	–	–	–	–
Chloride	37	–	–	–	–	–	–	–	–
Chlorobenzene	0.00015	Yes	–	–	–	–	–	–	–
Chloroform	0.00048	Yes	5.08E-07	–	2.23E-11	–	–	5.08E-07	0.0035
Chloromethane	0.000077	Yes	–	–	–	–	–	–	–
Chromium	0.026	–	–	–	–	–	–	–	–
Cobalt	0.00017	–	–	1.20E-05	–	–	–	1.20E-05	0.080
Copper	0.0023	–	–	–	–	–	–	–	–
Fluoride	0.52	–	–	–	–	–	–	–	–
Hexavalent Chromium	0.020	–	–	1.38E-02	–	–	–	1.38E-02	85
Iron	0.088	–	–	–	–	–	–	–	–
Lead	0.00020	–	–	–	–	–	–	–	–
Lithium	0.083	–	–	–	–	–	–	–	–
Manganese	0.0080	–	–	–	–	–	–	–	–
Molybdenum	0.0079	–	–	–	–	–	–	–	–
Nickel	0.0080	–	–	1.08E-05	–	–	–	1.08E-05	0.075
Nitrate	110	–	–	–	–	–	–	–	–
Selenium	0.0042	–	–	–	–	–	–	–	–
Strontium	0.88	–	–	–	–	–	–	–	–
Styrene	0.00014	Yes	–	–	–	–	–	–	–
Sulfate	127	–	–	–	–	–	–	–	–
Tetrachloroethene	0.00018	Yes	2.26E-08	–	2.80E-12	–	–	2.26E-08	0.00016
Tin	0.00010	–	–	–	–	–	–	–	–
Toluene	0.000072	Yes	–	–	–	–	–	–	–
Trichloroethene	0.011	Yes	2.18E-06	–	1.43E-08	–	–	2.18E-06	0.015
Trichloromonofluoromethane	0.00011	Yes	–	–	–	–	–	–	–
Vanadium	0.017	–	–	–	–	–	–	–	–
Xylenes (total)	0.00020	Yes	–	–	–	–	–	–	–
Zinc	0.0060	–	–	–	–	–	–	–	–
Americium-241	0.13	–	–	1.55E-05	–	–	–	1.55E-05	0.11
Carbon-14	12	–	–	3.53E-07	–	–	–	3.53E-07	0.0025
Gross alpha	6.2	–	–	–	–	–	–	–	–
Plutonium-238	0.24	–	–	3.34E-05	–	–	–	3.34E-05	0.23
Plutonium-239/240	0.70	–	–	9.84E-05	–	–	–	9.84E-05	0.68
Strontium-90	5.3	–	–	1.47E-06	–	–	–	1.47E-06	0.010
Technetium-99	6.1	–	–	3.63E-07	–	–	–	3.63E-07	0.0025
Tritium	2,700	Yes	3.73E-06	–	–	–	–	3.73E-06	0.026
Total Cumulative ELCR			9.51E-06	1.44E-02	1.56E-08	3.36E-06	5.50E-10	1.44E-02	100

[a] Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites" or as defined by EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."
[b] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
"– = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.

Attachment Table C-2. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment
Hazard quotient and cancer risk from inhalation of volatiles and semi-volatiles in sweat lodge vapor
CTUIR Sweat Lodge Scenario (Harris and Harper 2004, Appendix 4)

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Inhalation Intake of Analytes - Volatiles and Semi-Volatiles	I_{inh}	Calculated Value	mg/kg-day	Equation 34
Groundwater Concentration	C_{gw}	Analyte- specific	mg/L	ECF-100FR3-11-0024
Cumulative Volume of water used in a sweat	$V_{w,total}$	4	L	Harris and Harper, 2004
Radius of Sweat Lodge	r	1	m	Harris and Harper, 2004
Inhalation rate- adult	IR	25	m^3/day	Harris, 2008
Length of sweat event- adult[a]	ET	1/24	days/event	Harris and Harper, 2004
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	68	years	Harris and Harper, 2004
Average body weight - adult	BW	70	kg	Harris and Harper, 2004
Averaging time (noncarcinogens)[b]	AT	68	years	Harris and Harper, 2004
Averaging time (carcinogens)[b]	AT	70	years	Harris and Harper, 2004
The constant pi	π	3.14159	unitless	--
Inhalation Reference Concentration	RfC	Analyte-specific	mg/m^3	EPA, 2012
Inhalation Reference Dose	RfD_i	Calculated Value	mg/kg-day	Equation 51
Inhalation Unit Risk	IUR	Analyte-specific	$(\mu g/m^3)^{-1}$	EPA, 2012
Inhalation Cancer Slope Factor	CSF_i	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	Equation 50
Conversion factor	CF1	365	days/year	1 year = 365 days

[a] Exposure time of 1 hour provided in Harris and Harper, 2004 was replaced with 1/24 days/event so that the intake values have appropriate units (mg/kg-day or pCi) when calculated using the inhalation equations provided in Harris and Harper, 2004

[b] Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for carcinogens and 68 years for noncarcinogens to account for lifetime intake rather than annual intake

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments.*

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{gw} (mg/L)	I_{inh}(noncarcinogen) (mg/kg-day)	RfC[b] mg/m^3	RfD_i[b] mg/kg-day	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	1.42E-06	7.00E-03	2.00E-03	7.11E-04	0.25
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	3.41E-06	8.00E-01	2.29E-01	1.49E-05	0.0053
1,4-Dioxane	123-91-1	Yes[d]	0.0076	1.08E-04	3.00E+00	8.57E-01	1.26E-04	0.045
Acetone	67-64-1	Yes	0.0013	1.83E-05	3.10E+01	8.86E+00	2.06E-06	0.00074
Aluminum	7429-90-5	--	0.022	--[c]	5.00E-03	1.43E-03	--	--
Arsenic	7440-38-2	--	0.0090	--[c]	1.50E-05	4.29E-06	--	--
Barium	7440-39-3	--	0.11	--[c]	5.00E-04	1.43E-04	--	--
Boron	7440-42-8	--	0.14	--[c]	2.00E-02	5.71E-03	--	--
Bromomethane	74-83-9	Yes	0.00051	7.18E-06	5.00E-03	1.43E-03	5.02E-03	1.8
Chloride	16887-00-6	--	37	--[c]	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.13E-06	5.00E-02	1.43E-02	1.49E-04	0.053
Chloroform	67-66-3	Yes	0.00046	6.47E-06	9.80E-02	2.80E-02	2.31E-04	0.082
Chloromethane	74-87-3	Yes	0.000077	1.09E-06	9.00E-02	2.57E-02	4.26E-05	0.015
Chromium	7440-47-3	--	0.026	--[c]	--	--	--	--
Cobalt	7440-48-4	--	0.00017	--[c]	6.00E-06	1.71E-06	--	--
Copper	7440-50-8	--	0.0023	--[c]	--	--	--	--
Fluoride	16984-48-8	--	0.52	--[c]	1.30E-02	3.71E-03	--	--
Hexavalent Chromium	18540-29-9	--	0.020	--[c]	1.00E-04	2.86E-05	--	--
Iron	7439-89-6	--	0.083	--[c]	--	--	--	--
Lead	7439-92-1	--	0.00020	--[c]	--	--	--	--
Lithium	7439-93-2	--	0.035	--[c]	--	--	--	--
Manganese	7439-96-5	--	0.0060	--[c]	5.00E-05	1.43E-05	--	--
Molybdenum	7439-98-7	--	0.0079	--[c]	--	--	--	--
Nickel	7440-02-0	--	0.0050	--[c]	9.00E-05	2.57E-05	--	--
Nitrate	14797-55-8	--	110	--[c]	--	--	--	--
Selenium	7782-49-2	--	0.0042	--[c]	2.00E-02	5.71E-03	--	--
Strontium	7440-24-6	--	0.93	--[c]	--	--	--	--
Styrene	100-42-5	Yes	0.00014	1.82E-06	1.00E+00	2.86E-01	6.71E-06	0.0024
Sulfate	14808-79-8	--	127	--[c]	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	2.56E-06	4.00E-02	1.14E-02	2.24E-04	0.080
Tin	7440-31-5	--	0.00010	--[c]	--	--	--	--
Toluene	108-88-3	Yes	0.000072	1.02E-06	5.00E+00	1.43E+00	7.16E-07	0.00026
Trichloroethene	79-01-6	Yes	0.011	1.56E-04	2.00E-03	5.71E-04	2.74E-01	98
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.56E-06	7.00E-01	2.00E-01	7.82E-06	0.0028
Vanadium	7440-62-2	--	0.017	--[c]	--	--	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	2.84E-06	1.00E-01	2.86E-02	9.95E-05	0.036
Zinc	7440-66-6	--	0.0060	--[c]	--	--	--	--
Total HI							2.80E-01	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] Inhalation reference concentration (RfC) converted to inhalation reference dose (RfD$_i$) following EPA protocol (EPA 540/1-89/002) using formula RfDi (mg/kg-day) = RfC (mg/m^3) x 20 (m^3/day) x 1/70 (kg).

[c] Inhalation intake of nonvolatiles in sweat lodge is presented in table C-3

[d] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = Indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route

HI = hazard index.

HQ = hazard quotient.

EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final.*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{gw} (mg/L)	I_{inh}(carcinogen) (mg/kg-day)	IUR[b] $(\mu g/m^3)^{-1}$	CSF_i[b] $(mg/kg\text{-}day)^{-1}$	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	1.38E-06	2.60E-05	9.10E-02	1.26E-07	2.2
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	3.31E-06	1.10E-05	3.85E-02	1.28E-07	2.2
1,4-Dioxane	123-91-1	Yes[d]	0.0076	1.05E-04	7.70E-06	2.70E-02	2.83E-06	49
Acetone	67-64-1	Yes	0.0013	1.77E-05	--	--	--	--
Aluminum	7429-90-5	--	0.022	--[c]	--	--	--	--
Arsenic	7440-38-2	--	0.0090	--[c]	4.30E-03	1.51E+01	--	--
Barium	7440-39-3	--	0.11	--[c]	--	--	--	--
Boron	7440-42-8	--	0.14	--[c]	--	--	--	--
Bromomethane	74-83-9	Yes	0.00051	6.97E-06	--	--	--	--
Chloride	16887-00-6	--	37	--[c]	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.07E-06	--	--	--	--
Chloroform	67-66-3	Yes	0.00046	6.28E-06	2.30E-05	8.05E-02	5.06E-07	8.8
Chloromethane	74-87-3	Yes	0.000077	1.06E-06	--	--	--	--
Chromium	7440-47-3	--	0.026	--[c]	--	--	--	--
Cobalt	7440-48-4	--	0.00017	--[c]	9.00E-03	3.15E+01	--	--
Copper	7440-50-8	--	0.0023	--[c]	--	--	--	--
Fluoride	16984-48-8	--	0.52	--[c]	--	--	--	--
Hexavalent Chromium	18540-29-9	--	0.020	--[c]	8.40E-02	2.94E+02	--	--
Iron	7439-89-6	--	0.083	--[c]	--	--	--	--
Lead	7439-92-1	--	0.00020	--[c]	--	--	--	--
Lithium	7439-93-2	--	0.035	--[c]	--	--	--	--
Manganese	7439-96-5	--	0.0060	--[c]	--	--	--	--
Molybdenum	7439-98-7	--	0.0079	--[c]	--	--	--	--
Nickel	7440-02-0	--	0.0050	--[c]	2.60E-04	9.10E-01	--	--
Nitrate	14797-55-8	--	110	--[c]	--	--	--	--
Selenium	7782-49-2	--	0.0042	--[c]	--	--	--	--
Strontium	7440-24-6	--	0.93	--[c]	--	--	--	--
Styrene	100-42-5	Yes	0.00014	1.86E-06	--	--	--	--
Sulfate	14808-79-8	--	127	--[c]	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	2.48E-06	2.60E-07	9.10E-04	2.26E-09	0.039
Tin	7440-31-5	--	0.00010	--[c]	--	--	--	--
Toluene	108-88-3	Yes	0.000072	9.84E-07	--	--	--	--
Trichloroethene	79-01-6	Yes	0.011	1.52E-04	4.10E-06	1.44E-02	2.18E-06	38
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.52E-06	--	--	--	--
Vanadium	7440-62-2	--	0.017	--[c]	--	--	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	2.76E-06	--	--	--	--
Zinc	7440-66-6	--	0.0060	--[c]	--	--	--	--
Total ELCR							5.77E-06	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] Inhalation unit risk (IUR) converted to inhalation cancer slope factor (CSFi) following EPA protocol (EPA 540/1-89/002) using formula CSF_i (kg-day/mg) = IUR (m^3/µg) x 1/20 (m^3/day) x 70 (kg) x 1000 (µg/mg).

[c] Inhalation intake of nonvolatiles in sweat lodge is presented in table C-3

[d] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = Indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route

ELCR = excess lifetime cancer risk.

EPA 540/1-89/002 *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A)*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Attachment Table C-3. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment
Hazard quotient and cancer risk from inhalation of nonvolatiles in sweat lodge vapor
CTUIR Sweat Lodge Scenario (Harris and Harper 2004, Appendix 4)

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Inhalation Intake of Analytes - Nonvolatiles	I_{sub}	Calculated Value	mg/kg-day	Equation 35
Groundwater Concentration	C_{dw}	Analyte- specific	mg/L	ECF-100FR3-11-0024
Temperature inside of the sweat lodge[a]	T	338.7	K	Harris and Harper, 2004
Ideal gas law constant	R	0.06237	(mmHg-m^3)/(gmole-K)	Harris and Harper, 2004
Inhalation rate- adult	IR	25	m^3/day	Harris, 2008
Length of sweat event - adult[b]	ET	1/24	days/event	Harris and Harper, 2004
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	68	years	Harris and Harper, 2004
Average body weight - adult	BW	70	kg	Harris and Harper, 2004
Averaging time (noncarcinogens)[c]	AT	68	years	Harris and Harper, 2004
Averaging time (carcinogens)[c]	AT	70	years	Harris and Harper, 2004
Inhalation Reference Concentration	RfC	Analyte-specific	mg/m^3	EPA, 2012
Inhalation Reference Dose	RfD_i	Calculated Value	mg/kg-day	Equation 51
Inhalation Unit Risk	IUR	Analyte-specific	(µg/m^3)$^{-1}$	EPA, 2012
Inhalation Cancer Slope Factor	CSF_i	Analyte-specific	(mg/kg-day)$^{-1}$	Equation 50
Conversion Factor	CF1	365	days/year	1 year = 365 days
Molecular weight of water	MW_w	18	g/mole	Harris and Harper, 2004
Density of liquid water	ρ_w	1000	g/L	Harris and Harper, 2004

[a]Temperature of 369 K provided in Harris and Harper, 2004 was replaced with 338.7 K (150 °F) for consistency with stated assumption in Harris and Harper, 2004 that sweat lodge internal temperature is maintained at 150 °F.

[b] For Sweat lodge inhalation exposure, exposure time of 1 hour provided in Harris and Harper, 2004 was replaced with 1/24 days/event so that the intake values have appropriate units (mg/kg-day or pCi) when calculated using the inhalation equations provided in Harris and Harper, 2004

[c] Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for carcinogens and 68 years for noncarcinogens to account for lifetime intake rather than annual intake

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments* .

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	I_{sub}(noncarcinogen) (mg/kg-day)	RfC[a] (mg/m^3)	RfDi[b] (mg/kg-day)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	--(c)	7.00E-03	2.00E-03	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	--(c)	8.00E-01	2.29E-01	--	--
1,4-Dioxane	123-91-1	Yes[d]	0.0076	--(c)	3.00E+00	8.57E-01	--	--
Acetone	67-64-1	Yes	0.0013	--(c)	3.10E+01	8.86E+00	--	--
Aluminum	7429-90-5	--	0.022	5.43E-03	5.00E-03	1.43E-03	3.80E-02	0.35
Arsenic	7440-38-2	--	0.0080	2.18E-05	1.50E-05	4.29E-06	5.09E+00	47
Barium	7440-39-3	--	0.11	2.68E-04	5.00E-04	1.43E-04	1.88E+00	17
Boron	7440-42-8	--	0.14	3.32E-04	2.00E-02	5.71E-03	5.80E-02	0.53
Bromomethane	74-83-9	Yes	0.00051	--(c)	5.00E-03	1.43E-03	--	--
Chloride	16887-00-6	--	37	8.92E-02	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	--(c)	5.00E-02	1.43E-02	--	--
Chloroform	67-66-3	Yes	0.00046	--(c)	9.80E-02	2.80E-02	--	--
Chloromethane	74-87-3	Yes	0.000077	--(c)	9.00E-02	2.57E-02	--	--
Chromium	7440-47-3	--	0.028	6.40E-05	--	--	--	--
Cobalt	7440-48-4	--	0.00017	4.22E-07	6.00E-06	1.71E-06	2.46E-01	2.3
Copper	7440-50-8	--	0.0023	5.72E-06	--	--	--	--
Fluoride	16984-48-8	--	0.52	1.27E-06	1.30E-02	3.71E-03	3.41E-01	3.1
Hexavalent Chromium	18540-29-9	--	0.020	4.88E-05	1.00E-04	2.86E-05	1.71E+00	16
Iron	7439-89-6	--	0.083	2.01E-04	--	--	--	--
Lead	7439-92-1	--	0.00020	4.88E-07	--	--	--	--
Lithium	7439-93-2	--	0.035	8.53E-05	--	--	--	--
Manganese	7439-96-5	--	0.0080	1.46E-05	5.00E-05	1.43E-05	1.02E+00	9.4
Molybdenum	7439-98-7	--	0.0079	1.93E-05	--	--	--	--
Nickel	7440-02-0	--	0.0050	1.22E-05	9.00E-05	2.57E-05	4.74E-01	4.4
Nitrate	14797-55-8	--	110	2.67E-01	--	--	--	--
Selenium	7782-49-2	--	0.0042	1.03E-05	2.00E-02	5.71E-03	1.79E-03	0.017
Strontium	7440-24-6	--	0.93	2.27E-03	--	--	--	--
Styrene	100-42-5	Yes	0.00014	--(c)	1.00E+00	2.86E-01	--	--
Sulfate	14808-79-8	--	127	3.10E-01	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	--(c)	4.00E-02	1.14E-02	--	--
Tin	7440-31-5	--	0.00010	2.44E-07	--	--	--	--
Toluene	108-88-3	Yes	0.000072	--(c)	5.00E+00	1.43E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	--(c)	2.00E-03	5.71E-04	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	--(c)	7.00E-01	2.00E-01	--	--
Vanadium	7440-62-2	--	0.017	4.15E-05	--	--	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	--(c)	1.00E-01	2.86E-02	--	--
Zinc	7440-66-6	--	0.0060	1.46E-05	--	--	--	--
Total HI							1.09E+01	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] Inhalation reference concentration (RfC) converted to inhalation reference dose (RfDi) following EPA protocol (EPA 540/1-89/002) using formula RfDi (mg/kg-day) = RfC (mg/m^3) x 20 (m^3/day) x 1/70 (kg).

[c] Inhalation intake of volatiles and semi-volatiles in sweat lodge vapor is presented in Table C-2

[d]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.

HI= hazard index.

HQ = hazard quotient.

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	I_{sub}(carcinogen) (mg/kg-day)	IUR[a] (µg/m^3)$^{-1}$	CSF_i[b] (mg/kg-day)$^{-1}$	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	--(c)	2.60E-05	9.10E-02	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	--(c)	1.10E-05	3.85E-02	--	--
1,4-Dioxane	123-91-1	Yes[d]	0.0076	--(c)	7.70E-06	2.70E-02	--	--
Acetone	67-64-1	Yes	0.0013	--(c)	--	--	--	--
Aluminum	7429-90-5	--	0.022	5.27E-05	--	--	--	--
Arsenic	7440-38-2	--	0.0080	2.12E-05	4.30E-03	1.51E+01	3.19E-06	2.2
Barium	7440-39-3	--	0.11	2.61E-04	--	--	--	--
Boron	7440-42-8	--	0.14	3.22E-06	--	--	--	--
Bromomethane	74-83-9	Yes	0.00051	--(c)	--	--	--	--
Chloride	16887-00-6	--	37	8.67E-02	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	--(c)	--	--	--	--
Chloroform	67-66-3	Yes	0.00046	--(c)	2.30E-05	8.05E-02	--	--
Chloromethane	74-87-3	Yes	0.000077	--(c)	--	--	--	--
Chromium	7440-47-3	--	0.028	8.22E-05	--	--	--	--
Cobalt	7440-48-4	--	0.00017	4.10E-07	9.00E-03	3.15E+01	1.29E-05	0.091
Copper	7440-50-8	--	0.0023	5.55E-06	--	--	--	--
Fluoride	16984-48-8	--	0.52	1.23E-03	--	--	--	--
Hexavalent Chromium	18540-29-9	--	0.020	4.75E-05	8.40E-02	2.94E+02	1.39E-02	98
Iron	7439-89-6	--	0.083	1.95E-04	--	--	--	--
Lead	7439-92-1	--	0.00020	4.74E-07	--	--	--	--
Lithium	7439-93-2	--	0.035	8.29E-05	--	--	--	--
Manganese	7439-96-5	--	0.0080	1.42E-05	--	--	--	--
Molybdenum	7439-98-7	--	0.0079	1.88E-05	--	--	--	--
Nickel	7440-02-0	--	0.0050	1.18E-05	2.60E-04	9.10E-01	1.08E-05	0.076
Nitrate	14797-55-8	--	110	2.59E-01	--	--	--	--
Selenium	7782-49-2	--	0.0042	9.96E-06	--	--	--	--
Strontium	7440-24-6	--	0.93	2.20E-03	--	--	--	--
Styrene	100-42-5	Yes	0.00014	--(c)	--	--	--	--
Sulfate	14808-79-8	--	127	3.01E-01	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	--(c)	2.60E-07	9.10E-04	--	--
Tin	7440-31-5	--	0.00010	2.37E-07	--	--	--	--
Toluene	108-88-3	Yes	0.000072	--(c)	--	--	--	--
Trichloroethene	79-01-6	Yes	0.011	--(c)	4.10E-06	1.44E-02	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	--(c)	--	--	--	--
Vanadium	7440-62-2	--	0.017	4.03E-05	--	--	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	--(c)	--	--	--	--
Zinc	7440-66-6	--	0.0060	1.42E-05	--	--	--	--
Total ELCR							1.42E-02	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] Inhalation unit risk (IUR) converted to inhalation cancer slope factor (CSF_i) following EPA protocol (EPA 540/1-89/002) using formula CSF_i(kg-day/mg) = IUR (m^3/µg) x 1/20 (m^3/day) x 70 (kg) x 1000 (µg/mg).

[c] Inhalation intake of volatiles and semi-volatiles in sweat lodge vapor is presented in Table C-2

[d]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Attachment Table C-4. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment
Hazard quotient and cancer risk from dermal exposure to volatiles and semi-volatiles in sweet lodge vapor
CTUIR Sweet Lodge Scenario (Harris and Harper 2004, Appendix 4)

Model assumes 100% volatilization of volatiles and semi-volatiles; hence, dermal intake from volatiles and semi-volatiles in condensed water (Id,l) can be neglected and total dermal intake (Id,total) is equal to dermal intake from volatiles and semi-volatiles in sweat lodge vapor (Id,v)

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Dermal Intake of Analytes - Volatile Vapor (Id,total = Id,v)	$I_{d,total}$	Calculated Value	mg/kg-day	Equation 40
Groundwater Concentration	C_{dw}	Analyte- specific	mg/L	ECF-100FR3-11-0024
Cumulative Volume of water used in a sweat	V_{sweat}	4	L	Harris and Harper, 2004
Radius of Sweat Lodge	r	1	m	Harris and Harper, 2004
Skin Surface Area - adult	SA	1.8	m^2	Harris and Harper, 2004
Analyte-specific permeability constant	K_p	Analyte-specific	cm/hour	EPA/540/R/99/005
Length of sweat event - adult	ET	1	hours/event	Harris and Harper, 2004
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	68	years	Harris and Harper, 2004
Average body weight - adult	BW	70	kg	Harris and Harper, 2004
Averaging time (noncarcinogens)[a]	AT	68	years	Harris and Harper, 2004
Averaging time (carcinogens)[a]	AT	70	years	Harris and Harper, 2004
The constant pi	π	3.14159	unitless	--
Reference Dose - Oral	RfD_o	Analyte-specific	mg/kg-day	EPA, 2012
Gastrointestinal Absorption Factor	GIABS	Analyte-specific	unitless	EPA, 2012
Cancer Slope Factor - Oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	EPA, 2012
Conversion factor	CF1	365	days/year	1 year = 365 days
Conversion factor	CF2	0.01	m/cm	1 m = 100 cm

[a] Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for carcinogens and 68 years for noncarcinogens to account for lifetime intake rather than annual intake

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	K_p[b] (cm/hour)	$I_{d,total}$(noncarcinogen) (mg/kg-day)	RfD_o[a] (mg/kg-day)	GIABS[a] (unitless)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	1.03E-10	6.00E-03	1.00E+00	1.72E-08	0.026
1,4-Dichlorobenzene	106-46-7	Yes	0.00034	4.20E-02	2.48E-08	7.00E-02	1.00E+00	3.54E-08	0.054
1,4-Dioxane	123-91-1	Yes[c]	0.0076	3.30E-04	6.16E-10	3.00E-02	1.00E+00	2.05E-08	0.031
Acetone[d]	67-64-1	Yes	0.0013	5.12E-04	1.62E-10	9.00E-01	1.00E+00	1.80E-10	0.00027
Aluminum	7429-90-5	--	0.022	1.00E-03	--(c)	1.00E+00	1.00E+00	--	--
Arsenic	7440-38-2	--	0.0080	1.00E-03	--(c)	3.00E-04	1.00E+00	--	--
Barium	7440-39-3	--	0.11	1.00E-03	--(c)	2.00E-01	7.00E-02	--	--
Boron	7440-42-8	--	0.14	1.00E-03	--(c)	2.00E-01	1.00E+00	--	--
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	3.47E-10	1.40E-03	1.00E+00	2.48E-07	0.38
Chloride	16887-00-6	--	37	1.00E-03	--(c)	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	1.08E-08	2.00E-02	1.00E+00	5.18E-08	0.079
Chloroform	67-66-3	Yes	0.00046	6.80E-03	7.80E-10	1.00E-02	1.00E+00	7.80E-08	0.12
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	6.24E-11	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	--(c)	1.50E+00	1.30E-02	--	--
Cobalt	7440-48-4	--	0.00017	4.00E-04	--(c)	3.00E-04	1.00E+00	--	--
Copper	7440-50-8	--	0.0023	1.00E-03	--(c)	4.00E-02	1.00E+00	--	--
Fluoride	16984-48-8	--	0.52	1.00E-03	--(c)	6.00E-02	1.00E+00	--	--
Hexavalent Chromium	18540-29-9	--	0.020	2.00E-03	--(c)	3.00E-03	2.50E-02	--	--
Iron	7439-89-6	--	0.083	1.00E-03	--(c)	7.00E-01	1.00E+00	--	--
Lead	7439-92-1	--	0.00020	1.00E-04	--(c)	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	--(c)	2.00E-03	1.00E+00	--	--
Manganese	7439-96-5	--	0.0080	1.00E-03	--(c)	2.40E-02	4.00E-02	--	--
Molybdenum	7439-98-7	--	0.0079	1.00E-03	--(c)	5.00E-03	1.00E+00	--	--
Nickel	7440-02-0	--	0.0050	2.00E-04	--(c)	2.00E-02	4.00E-02	--	--
Nitrate	14797-55-8	--	110	1.00E-03	--(c)	7.10E+00	1.00E+00	--	--
Selenium	7782-49-2	--	0.0042	1.00E-03	--(c)	5.00E-03	1.00E+00	--	--
Strontium	7440-24-6	--	0.93	1.00E-03	--(c)	6.00E-01	1.00E+00	--	--
Styrene	100-42-5	Yes	0.00014	3.70E-02	1.23E-08	2.00E-01	1.00E+00	6.15E-09	0.0094
Sulfate	14808-79-8	--	127	1.00E-03	--(c)	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	3.30E-02	1.46E-08	6.00E-03	1.00E+00	2.43E-07	0.37
Tin	7440-31-5	--	0.00010	1.00E-03	--(c)	6.00E-01	1.00E+00	--	--
Toluene	108-88-3	Yes	0.000072	3.10E-02	5.48E-10	6.00E-02	1.00E+00	6.85E-09	0.010
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	3.24E-08	5.00E-04	1.00E+00	6.48E-05	99
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	9.51E-10	3.00E-01	1.00E+00	1.17E-09	0.0018
Vanadium	7440-62-2	--	0.017	1.00E-03	--(c)	5.00E-03	1.00E+00	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	2.60E-08	2.00E-01	1.00E+00	1.30E-08	0.020
Zinc	7440-66-6	--	0.0060	6.00E-04	--(c)	3.00E-01	1.00E+00	--	--
Total HI								6.55E-05	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics).

[c] Dermal intake of nonvolatiles in sweat lodge vapor is presented in Table C-6

[d] K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).

*Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.

HI= hazard index.

HQ = hazard quotient.

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	K_p[b] (cm/hour)	$I_{d,total}$(carcinogen) (mg/kg-day)	CSF_o[a] $(mg/kg\text{-}day)^{-1}$	GIABS[a] (unitless)	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	1.00E-10	9.10E-02	1.00E+00	9.12E-12	0.59
1,4-Dichlorobenzene	106-46-7	Yes	0.00034	4.20E-02	2.40E-08	5.40E-03	1.00E+00	1.30E-11	0.83
1,4-Dioxane	123-91-1	Yes[c]	0.0076	3.30E-04	5.98E-10	1.00E-01	1.00E+00	5.98E-11	3.8
Acetone[d]	67-64-1	Yes	0.0013	5.12E-04	1.57E-10	--	1.00E+00	--	--
Aluminum	7429-90-5	--	0.022	1.00E-03	--(c)	--	1.00E+00	--	--
Arsenic	7440-38-2	--	0.0080	1.00E-03	--(c)	1.50E+00	1.00E+00	--	--
Barium	7440-39-3	--	0.11	1.00E-03	--(c)	--	7.00E-02	--	--
Boron	7440-42-8	--	0.14	1.00E-03	--(c)	--	1.00E+00	--	--
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	3.37E-10	--	1.00E+00	--	--
Chloride	16887-00-6	--	37	1.00E-03	--(c)	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	1.05E-08	--	1.00E+00	--	--
Chloroform	67-66-3	Yes	0.00046	6.80E-03	7.58E-10	5.10E-02	1.00E+00	2.29E-11	1.5
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	6.06E-11	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	--(c)	--	1.30E-02	--	--
Cobalt	7440-48-4	--	0.00017	4.00E-04	--(c)	--	1.00E+00	--	--
Copper	7440-50-8	--	0.0023	1.00E-03	--(c)	--	1.00E+00	--	--
Fluoride	16984-48-8	--	0.52	1.00E-03	--(c)	--	1.00E+00	--	--
Hexavalent Chromium	18540-29-9	--	0.020	2.00E-03	--(c)	--	2.50E-02	--	--
Iron	7439-89-6	--	0.083	1.00E-03	--(c)	--	1.00E+00	--	--
Lead	7439-92-1	--	0.00020	1.00E-04	--(c)	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	--(c)	--	1.00E+00	--	--
Manganese	7439-96-5	--	0.0080	1.00E-03	--(c)	--	4.00E-02	--	--
Molybdenum	7439-98-7	--	0.0079	1.00E-03	--(c)	--	1.00E+00	--	--
Nickel	7440-02-0	--	0.0050	2.00E-04	--(c)	--	4.00E-02	--	--
Nitrate	14797-55-8	--	110	1.00E-03	--(c)	--	1.00E+00	--	--
Selenium	7782-49-2	--	0.0042	1.00E-03	--(c)	--	1.00E+00	--	--
Strontium	7440-24-6	--	0.93	1.00E-03	--(c)	--	1.00E+00	--	--
Styrene	100-42-5	Yes	0.00014	3.70E-02	1.19E-08	--	1.00E+00	--	--
Sulfate	14808-79-8	--	127	1.00E-03	--(c)	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	3.30E-02	1.42E-08	2.10E-03	1.00E+00	2.98E-12	0.19
Tin	7440-31-5	--	0.00010	1.00E-03	--(c)	--	1.00E+00	--	--
Toluene	108-88-3	Yes	0.000072	3.10E-02	5.32E-10	--	1.00E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	3.15E-08	4.60E-02	1.00E+00	1.45E-09	93
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	3.41E-10	--	1.00E+00	--	--
Vanadium	7440-62-2	--	0.017	1.00E-03	--(c)	--	1.00E+00	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	2.53E-08	--	1.00E+00	--	--
Zinc	7440-66-6	--	0.0060	6.00E-04	--(c)	--	1.00E+00	--	--
Total ELCR								1.56E-09	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics).

[c] Dermal intake of nonvolatiles in sweat lodge vapor is presented in Table C-6

[d] K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).

*Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Attachment Table C-5. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment
Hazard quotient and cancer risk from dermal exposure to nonvolatile compounds in sweat lodge condensed water
CTUIR Sweat Lodge Scenario (Harris and Harper 2004, Appendix 4)

Model assumes concentration of nonvolatiles in condensed water is equal to concentration in water used to create steam

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Dermal Intake of Analytes - Nonvolatiles Condensed Liquid	I_{dj}	Calculated Value	mg/kg-day	Equation 43
Groundwater Concentration	C_{dw}	Analyte- specific	mg/L	ECF-100FR3-11-0024
Skin Surface Area - adult	SA	1.8	m^2	Harris and Harper, 2004
Analyte-specific permeability constant	K_p	Analyte- specific	cm/hour	EPA/540/R/99/005
Length of sweat event - adult	ET	1	hours/event	Harris and Harper, 2004
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	68	years	Harris and Harper, 2004
Average body weight - adult	BW	70	kg	Harris and Harper, 2004
Averaging time (noncarcinogens)[a]	AT	68	years	Harris and Harper, 2004
Averaging time (carcinogens)[a]	AT	70	years	Harris and Harper, 2004
Reference Dose - Oral	RfD_o	Analyte-specific	mg/kg-day	EPA, 2012
Gastrointestinal Absorption Factor	GIABS	Analyte-specific	unitless	EPA, 2012
Cancer Slope Factor - Oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	EPA, 2012
Conversion factor	CF1	365	days/year	1 year = 365 days
Conversion factor	CF3	10	$L/m^2\text{-}cm$	$1\ L = 0.01\ m^2 * 10\ cm$

[a] Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for carcinogens and 68 years for noncarcinogens to account for lifetime intake rather than annual intake

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[c]	C_{dw} (mg/L)	K_p[b] (cm/hour)	I_{dj}(noncarcinogen) (mg/kg-day)	RfD_o[a] (mg/kg-day)	GIABS[a] (unitless)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	--(c)	6.00E-03	1.00E+00	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00034	4.20E-02	--(c)	7.00E-02	1.00E+00	--	--
1,4-Dioxane	123-91-1	Yes[e]	0.0076	3.90E-04	--(c)	3.00E-02	1.00E+00	--	--
Acetone[d]	67-64-1	Yes	0.0013	5.12E-04	--(c)	9.00E-01	1.00E+00	--	--
Aluminum	7429-90-5	--	0.022	1.00E-03	5.72E-08	1.00E+00	1.00E+00	5.72E-08	0.0035
Arsenic	7440-38-2	--	0.0080	1.00E-03	2.30E-08	3.00E-04	1.00E+00	7.68E-05	4.7
Barium	7440-39-3	--	0.11	1.00E-03	2.83E-05	2.00E-01	7.00E-02	2.02E-03	1.2
Boron	7440-42-8	--	0.14	1.00E-03	3.50E-05	2.00E-01	1.00E+00	1.75E-04	0.11
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	--(c)	1.40E-03	1.00E+00	--	--
Chloride	16887-00-6	--	37	1.00E-03	8.41E-05	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	--(c)	2.00E-02	1.00E+00	--	--
Chloroform	67-66-3	Yes	0.00046	6.80E-03	--(c)	1.00E-02	1.00E+00	--	--
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	--(c)	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	6.75E-06	1.50E+00	1.30E-02	3.46E-04	0.21
Cobalt	7440-48-4	--	0.00017	4.00E-04	1.78E-08	3.00E-04	1.00E+00	5.93E-05	0.037
Copper	7440-50-8	--	0.0023	1.00E-03	6.03E-07	4.00E-02	1.00E+00	1.51E-05	0.0093
Fluoride	16984-48-8	--	0.52	1.00E-03	1.36E-04	6.00E-02	1.00E+00	2.23E-03	1.4
Hexavalent Chromium	18540-29-9	--	0.020	2.00E-03	1.05E-05	3.00E-03	2.50E-02	1.32E-01	85
Iron	7439-89-6	--	0.083	1.00E-03	2.12E-05	7.00E-01	1.00E+00	3.03E-05	0.019
Lead	7439-92-1	--	0.00020	1.00E-04	5.14E-08	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	9.00E-06	2.00E-03	1.00E+00	4.50E-03	2.8
Manganese	7439-96-5	--	0.0080	1.00E-03	1.54E-08	2.40E-02	4.00E-02	1.61E-03	0.98
Molybdenum	7439-98-7	--	0.0079	1.00E-03	2.04E-08	5.00E-03	1.00E+00	4.08E-04	0.25
Nickel	7440-02-0	--	0.0050	2.00E-04	2.57E-07	2.00E-02	4.00E-02	3.21E-04	0.20
Nitrate	14797-55-8	--	110	1.00E-03	2.82E-02	7.10E+00	1.00E+00	3.97E-03	2.4
Selenium	7782-49-2	--	0.0042	1.00E-03	1.08E-06	5.00E-03	1.00E+00	2.16E-04	0.13
Strontium	7440-24-6	--	0.93	1.00E-03	2.38E-04	6.00E-01	1.00E+00	3.98E-04	0.25
Styrene	100-42-5	Yes	0.00014	3.70E-02	--(c)	2.00E-01	1.00E+00	--	--
Sulfate	14808-79-8	--	127	1.00E-03	3.27E-02	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00014	3.30E-02	--(c)	8.00E-03	1.00E+00	--	--
Tin	7440-31-5	--	0.00010	1.00E-03	2.57E-08	6.00E-01	1.00E+00	4.29E-08	0.000026
Toluene	108-88-3	Yes	0.000072	3.10E-02	--(c)	8.00E-02	1.00E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	--(c)	5.00E-04	1.00E+00	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	--(c)	3.00E-01	1.00E+00	--	--
Vanadium	7440-62-2	--	0.017	1.00E-03	4.37E-06	5.00E-03	1.00E+00	8.74E-04	0.54
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	--(c)	2.00E-01	1.00E+00	--	--
Zinc	7440-66-6	--	0.0060	6.00E-04	9.26E-07	3.00E-01	1.00E+00	3.09E-06	0.0019
Total HI								1.62E-01	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics).

[c] Model assumes 100% volatilization of volatiles and semi-volatiles; hence, dermal intake from volatiles and semi-volatiles in condensed water can be neglected (Harris and Harper 2004, Appendix 4).

[d] K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).

[e] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.

HI= hazard index.

HQ = hazard quotient.

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[c]	C_{dw} (mg/L)	K_p[b] (cm/hour)	I_{dj}(carcinogen) (mg/kg-day)	CSF_o[a] $(mg/kg\text{-}day)^{-1}$	GIABS[a] (unitless)	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	--(c)	9.10E-02	1.00E+00	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00034	4.20E-02	--(c)	5.40E-03	1.00E+00	--	--
1,4-Dioxane	123-91-1	Yes[e]	0.0076	3.90E-04	--(c)	1.00E-01	1.00E+00	--	--
Acetone[d]	67-64-1	Yes	0.0013	5.12E-04	--(c)	--	1.00E+00	--	--
Aluminum	7429-90-5	--	0.022	1.00E-03	5.56E-08	--	1.00E+00	--	--
Arsenic	7440-38-2	--	0.0080	1.00E-03	2.24E-08	1.50E+00	1.00E+00	3.36E-08	100
Barium	7440-38-3	--	0.11	1.00E-03	2.75E-05	--	7.00E-02	--	--
Boron	7440-42-8	--	0.14	1.00E-03	3.40E-05	--	1.00E+00	--	--
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	--(c)	--	1.00E+00	--	--
Chloride	16887-00-6	--	37	1.00E-03	9.14E-05	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	--(c)	--	1.00E+00	--	--
Chloroform	67-66-3	Yes	0.00046	6.80E-03	--(c)	3.10E-02	1.00E+00	--	--
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	--(c)	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	6.56E-06	--	1.30E-02	--	--
Cobalt	7440-48-4	--	0.00017	4.00E-04	1.73E-08	--	1.00E+00	--	--
Copper	7440-50-8	--	0.0023	1.00E-03	5.86E-07	--	1.00E+00	--	--
Fluoride	16984-48-8	--	0.52	1.00E-03	1.30E-04	--	1.00E+00	--	--
Hexavalent Chromium	18540-29-9	--	0.020	2.00E-03	1.02E-05	--	2.50E-02	--	--
Iron	7439-89-6	--	0.083	1.00E-03	2.06E-05	--	1.00E+00	--	--
Lead	7439-92-1	--	0.00020	1.00E-04	5.00E-08	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	8.74E-08	--	1.00E+00	--	--
Manganese	7439-96-5	--	0.0080	1.00E-03	1.50E-08	--	4.00E-02	--	--
Molybdenum	7439-98-7	--	0.0079	1.00E-03	1.98E-08	--	1.00E+00	--	--
Nickel	7440-02-0	--	0.0050	2.00E-04	2.50E-07	--	4.00E-02	--	--
Nitrate	14797-55-8	--	110	1.00E-03	2.74E-02	--	1.00E+00	--	--
Selenium	7782-49-2	--	0.0042	1.00E-03	1.05E-06	--	1.00E+00	--	--
Strontium	7440-24-6	--	0.93	1.00E-03	2.32E-04	--	1.00E+00	--	--
Styrene	100-42-5	Yes	0.00014	3.70E-02	--(c)	--	1.00E+00	--	--
Sulfate	14808-79-8	--	127	1.00E-03	3.17E-02	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	3.30E-02	--(c)	2.10E-03	1.00E+00	--	--
Tin	7440-31-5	--	0.00010	1.00E-03	2.50E-08	--	1.00E+00	--	--
Toluene	108-88-3	Yes	0.000072	3.10E-02	--(c)	--	1.00E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	--(c)	4.60E-02	1.00E+00	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	--(c)	--	1.00E+00	--	--
Vanadium	7440-62-2	--	0.017	1.00E-03	4.25E-06	--	1.00E+00	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	--(c)	--	1.00E+00	--	--
Zinc	7440-66-6	--	0.0060	6.00E-04	8.99E-07	--	1.00E+00	--	--
Total ELCR								3.36E-06	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics).

[c] Model assumes 100% volatilization of volatiles and semi-volatiles; hence, dermal intake from volatiles and semi-volatiles in condensed water can be neglected (Harris and Harper 2004, Appendix 4).

[d] K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).

[e] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Attachment Table C-6. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment
Hazard quotient and cancer risk from dermal exposure to nonvolatile compounds in sweat lodge vapor
CTUIR Sweat Lodge Scenario (Harris and Harper 2004, Appendix 4)

	Intake Parameter Values			
Parameter	Symbol	Value	Unit	Source
Dermal Intake of Analytes - Nonvolatiles Vapor	I_{dv}	Calculated Value	mg/kg-day	Equation 64
Groundwater Concentration	C_{dw}	Analyte- specific	mg/L	ECF-100FR3-11-0024
Skin Surface Area - adult	SA	1.8	m^2	Harris and Harper, 2004
Analyte-specific permeability constant	K_p	Analyte- specific	cm/hour	EPA/540/R/99/005
Length of sweat event-adult	ET	1	hours/event	Harris and Harper, 2004
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	68	years	Harris and Harper, 2004
Average body weight - adult	BW	70	kg	Harris and Harper, 2004
Averaging time (noncarcinogens)[a]	AT	68	years	Harris and Harper, 2004
Averaging time (carcinogens)[a]	AT	70	years	Harris and Harper, 2004
Molecular weight of water	MW_w	18	g/mole	Harris and Harper, 2004
Ideal gas law constant[b]	R	62.37	(mmHg-L)/(gmole-K)	Harris and Harper, 2004
Temperature inside of the sweat lodge[c]	T	338.7	K	Harris and Harper, 2004
Density of liquid water	ρ_w	1000	g/L	Harris and Harper, 2004
Reference Dose - Oral	RfD_o	Analyte-specific	mg/kg-day	EPA, 2012
GastroIntestinal Absorption Factor	GIABS	Analyte-specific	unitless	EPA, 2012
Cancer Slope Factor - Oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	EPA, 2012
Conversion factor	CF1	365	days/year	1 year = 365 days
Conversion factor	CF3	10	$L/m^2\text{-}cm$	$1\ L = 0.01\ m^2 * 10\ cm$

[a] Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for carcinogens and 68 years for noncarcinogens to account for lifetime intake rather than annual intake

[b] Ideal gas law of 0.06237 mmHg-m^3/gmole-K provided in Harris and Harper, 2004 was replaced with 62.37 mmHg-L/gmole-K so that intake values have appropriate units (mg/kg-day) when calculated using the equations provided in Harris and Harper, 2004, Equations 15 and 20.

[c] Temperature of 338 K provided in Harris and Harper, 2004 was replaced with 338.7 K (150°F) for consistency with stated assumption in Harris and Harper, 2004 that sweat lodge internal temperature is maintained at 150°F.

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*
EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	K_p[b] (cm/hour)	I_{dv}(noncarcinogen) (mg/kg-day)	RfD_o[c] (mg/kg-day)	GIABS[d] (unitless)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	--(c)	6.00E-03	1.00E+00	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	4.20E-02	--(c)	7.00E-02	1.00E+00	--	--
1,4-Dioxane	123-91-1	Yes[e]	0.0076	3.30E-04	--(c)	3.00E-02	1.00E+00	--	--
Acetone[e]	67-64-1	Yes	0.0013	5.12E-04	--(c)	9.00E-01	1.00E+00	--	--
Aluminum	7429-90-5	--	0.022	1.00E-03	9.37E-10	1.00E+00	1.00E+00	9.37E-10	0.0085
Arsenic	7440-38-2	--	0.0080	1.00E-03	3.77E-10	3.00E-04	1.00E+00	1.26E-06	4.7
Barium	7440-39-3	--	0.11	1.00E-03	4.63E-09	3.00E-01	7.00E-02	3.31E-07	1.2
Boron	7440-42-8	--	0.14	1.00E-03	5.73E-09	2.00E-01	1.00E+00	2.87E-08	0.11
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	--(c)	1.40E-03	1.00E+00	--	--
Chloride	16887-00-6	--	37	1.00E-03	1.54E-08	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	--(c)	2.00E-02	1.00E+00	--	--
Chloroform	67-66-3	Yes	0.00046	6.80E-03	--(c)	1.00E-02	1.00E+00	--	--
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	--(c)	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	1.11E-09	1.50E+00	1.90E-02	5.67E-08	0.21
Cobalt	7440-48-4	--	0.00017	4.00E-04	2.92E-12	3.00E-04	1.00E+00	9.72E-09	0.087
Copper	7440-50-8	--	0.0023	1.00E-03	9.88E-11	4.00E-02	1.00E+00	2.47E-09	0.0089
Fluoride	16984-48-8	--	0.52	1.00E-03	2.19E-08	6.00E-02	1.00E+00	3.65E-07	1.4
Hexavalent Chromium	18540-29-9	--	0.020	2.00E-03	1.68E-08	3.00E-03	2.50E-02	2.25E-05	85
Iron	7439-89-6	--	0.083	1.00E-03	3.48E-09	7.00E-01	1.00E+00	4.97E-09	0.019
Lead	7439-92-1	--	0.00020	1.00E-04	8.43E-13	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	1.47E-09	3.00E-03	1.00E+00	7.37E-07	2.8
Manganese	7439-96-5	--	0.0080	1.00E-03	2.53E-10	2.40E-02	4.00E-02	2.63E-07	0.99
Molybdenum	7439-98-7	--	0.0079	1.00E-03	3.34E-10	5.00E-03	1.00E+00	6.68E-08	0.25
Nickel	7440-02-0	--	0.0050	2.00E-04	4.21E-11	2.00E-02	4.00E-02	5.27E-08	0.20
Nitrate	14797-55-8	--	110	1.00E-03	4.61E-08	7.10E+00	1.00E+00	6.50E-07	2.4
Selenium	7782-49-2	--	0.0042	1.00E-03	1.77E-10	5.00E-03	1.00E+00	3.54E-08	0.13
Strontium	7440-24-6	--	0.93	1.00E-03	3.92E-09	6.00E-01	1.00E+00	6.53E-08	0.25
Styrene	100-42-5	Yes	0.00014	3.70E-02	--(c)	2.00E-01	1.00E+00	--	--
Sulfate	14808-79-8	--	127	1.00E-03	5.35E-08	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00014	3.30E-02	--(c)	6.00E-03	1.00E+00	--	--
Tin	7440-31-5	--	0.00010	1.00E-03	4.21E-12	6.00E-01	1.00E+00	7.02E-12	0.000028
Toluene	108-88-3	Yes	0.000072	3.10E-02	--(c)	8.00E-02	1.00E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	--(c)	5.00E-04	1.00E+00	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	--(c)	3.00E-01	1.00E+00	--	--
Vanadium	7440-62-2	--	0.017	1.00E-03	7.18E-10	5.00E-03	1.00E+00	1.43E-07	0.54
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	--(c)	2.00E-01	1.00E+00	--	--
Zinc	7440-66-6	--	0.0060	6.00E-04	1.52E-10	3.00E-01	1.00E+00	5.06E-10	0.0019
Total HI								2.66E-05	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics).
[c] Dermal intake of volatiles and semi-volatiles in sweat lodge vapor is presented in table C-4
[d] K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).
[e] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.
HI = hazard index.
HQ = hazard quotient.
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	K_p[b] (cm/hour)	I_{dv}(carcinogen) (mg/kg-day)	CSF_o[c] $(mg/kg\text{-}day)^{-1}$	GIABS[d] (unitless)	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	--(c)	9.10E-02	1.00E+00	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	4.20E-02	--(c)	5.40E-03	1.00E+00	--	--
1,4-Dioxane	123-91-1	Yes[e]	0.0076	3.30E-04	--(c)	1.00E-01	1.00E+00	--	--
Acetone[e]	67-64-1	Yes	0.0013	5.12E-04	--(c)	--	1.00E+00	--	--
Aluminum	7429-90-5	--	0.022	1.00E-03	9.11E-10	--	1.00E+00	--	--
Arsenic	7440-38-2	--	0.0080	1.00E-03	3.67E-10	1.50E+00	1.00E+00	5.50E-10	100
Barium	7440-39-3	--	0.11	1.00E-03	4.50E-09	--	7.00E-02	--	--
Boron	7440-42-8	--	0.14	1.00E-03	5.57E-09	--	1.00E+00	--	--
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	--(c)	--	1.00E+00	--	--
Chloride	16887-00-6	--	37	1.00E-03	1.50E-08	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	--(c)	--	1.00E+00	--	--
Chloroform	67-66-3	Yes	0.00046	6.80E-03	--(c)	3.10E-02	1.00E+00	--	--
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	--(c)	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	1.07E-09	--	1.30E-02	--	--
Cobalt	7440-48-4	--	0.00017	4.00E-04	2.83E-12	--	1.00E+00	--	--
Copper	7440-50-8	--	0.0023	1.00E-03	9.60E-11	--	1.00E+00	--	--
Fluoride	16984-48-8	--	0.52	1.00E-03	2.13E-09	--	1.00E+00	--	--
Hexavalent Chromium	18540-29-9	--	0.020	2.00E-03	1.64E-09	--	2.50E-02	--	--
Iron	7439-89-6	--	0.083	1.00E-03	3.38E-09	--	1.00E+00	--	--
Lead	7439-92-1	--	0.00020	1.00E-04	8.19E-13	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	1.43E-09	--	1.00E+00	--	--
Manganese	7439-96-5	--	0.0080	1.00E-03	2.46E-10	--	4.00E-02	--	--
Molybdenum	7439-98-7	--	0.0079	1.00E-03	3.25E-10	--	1.00E+00	--	--
Nickel	7440-02-0	--	0.0050	2.00E-04	4.08E-11	--	4.00E-02	--	--
Nitrate	14797-55-8	--	110	1.00E-03	4.48E-08	--	1.00E+00	--	--
Selenium	7782-49-2	--	0.0042	1.00E-03	1.72E-10	--	1.00E+00	--	--
Strontium	7440-24-6	--	0.93	1.00E-03	3.80E-09	--	1.00E+00	--	--
Styrene	100-42-5	Yes	0.00014	3.70E-02	--(c)	--	1.00E+00	--	--
Sulfate	14808-79-8	--	127	1.00E-03	5.20E-08	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	3.30E-02	--(c)	2.10E-03	1.00E+00	--	--
Tin	7440-31-5	--	0.00010	1.00E-03	4.09E-12	--	1.00E+00	--	--
Toluene	108-88-3	Yes	0.000072	3.10E-02	--(c)	--	1.00E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	--(c)	4.60E-02	1.00E+00	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	--(c)	--	1.00E+00	--	--
Vanadium	7440-62-2	--	0.017	1.00E-03	6.96E-10	--	1.00E+00	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	--(c)	--	1.00E+00	--	--
Zinc	7440-66-6	--	0.0060	6.00E-04	1.47E-10	--	1.00E+00	--	--
Total ELCR								5.50E-10	100

[a] EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics).
[c] Dermal intake of volatiles and semi-volatiles in sweat lodge vapor is presented in table C-4
[d] K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).
[e] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Attachment Table C-7. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment Cancer risk from inhalation of volatile radioactive contaminants in sweat lodge vapor CTUIR Sweat Lodge Scenario (Harris and Harper 2004, Appendix 4)

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Inhalation Intake of Analytes - Volatile Radionuclides	I_{inh}	Calculated Value	pCi	Equation 33
Groundwater Concentration	C_{dw}	Analyte- specific	pCi/L	ECF-100FR3-11-0024
Cumulative Volume of water used in a sweat	$V_{w,total}$	4	L	Harris and Harper, 2004
Radius of Sweat Lodge	r	1	m	Harris and Harper, 2004
Inhalation rate- adult	IR	25	m^3/day	Harris, 2008
Length of sweat event- adult[a]	ET	1/24	days/event	Harris and Harper, 2004
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	68	years	Harris and Harper, 2004
The constant pi	π	3.14159	unitless	--
Slope Factor - Inhalation	SF_i	Analyte- specific	risk/pCi	EPA, 2001

[a] For Sweat lodge inhalation exposure, exposure time of 1 hour provided in Harris and Harper, 2004 was replaced with 1/24 days/event so that the intake values have appropriate units (mg/kg-day or pCi) when calculated using the inhalation equations provided in Harris and Harper, 2004

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*
Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments*.

Cancer risk calculation

Radioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (pCi/L)	I_{inh} (radiological) (pCi)	SF_i[b] (risk/pCi)	Risk (unitless)	% Contribution
Americium-241	14596-10-2	--	0.13	--(c)	2.81E-08	--	--
Carbon-14	14762-75-5	--	12	--(c)	7.07E-12	--	--
Gross alpha	12587-46-1	--	6.2	--(c)	--	--	--
Plutonium-238	13981-16-3	--	0.24	--(c)	3.36E-08	--	--
Plutonium-239/240	15117-48-3	--	0.70	--(c)	3.33E-08	--	--
Strontium-90	10098-97-2	--	3.3	--(c)	1.05E-10	--	--
Technetium-99	14133-76-7	--	6.1	--(c)	1.41E-11	--	--
Tritium	10028-17-8	Yes	2,700	6.67E+07	5.62E-14	3.75E-06	100
Total ELCR						3.75E-06	100

[a] Volatile radioactive contaminants as defined by EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

[b] EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

[c] Inhalation intake of nonvolatile radionuclides in sweat lodge is presented in Table C-8

-- = Indicates radionuclide toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

EPA/540/R-92/003 *Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part B, Development of Preliminary Remediation Goals,*.

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Attachment Table C-8. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment Cancer risk from inhalation of nonvolatile radioactive contaminants in sweat lodge vapor CTUIR Sweat Lodge Scenario (Harris and Harper 2004, Appendix 4)

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Inhalation Intake of Analytes - Nonvolatile Radionuclides	I_{inh}	Calculated Value	pCi	Equation 38
Groundwater Concentration	C_{dw}	Analyte- specific	pCi/L	ECF-100FR3-11-0024
Cumulative Volume of water used in a sweat	$V_{w,total}$	4	L	Harris and Harper, 2004
Inhalation rate- adult	IR	25	m^3/day	Harris, 2008
Length of sweat event- adult[a]	ET	1/24	days/event	Harris and Harper, 2004
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	68	years	Harris and Harper, 2004
Molecular weight of water	MW_w	18	g/mole	Harris and Harper, 2004
Density of liquid water	ρ_w	1000	g/L	Harris and Harper, 2004
Temperature of the sweat lodge[b]	T	338.7	K	Harris and Harper, 2004
Ideal gas law constant	R	0.06237	(mmHg-m^3)/(gmole-K)	Harris and Harper, 2004
Slope Factor - inhalation	SF_i	Analyte-specific	risk/pCi	EPA, 2001

[a] Exposure time of 1 hour provided in Harris and Harper, 2004 was replaced with 1/24 days/event so that the intake values have appropriate units (mg/kg-day or pCi) when calculated using the inhalation equations provided in Harris and Harper, 2004

[b] Temperature of 389 K provided in Harris and Harper, 2004 was replaced with 338.7 K (150 °F) for consistency with stated assumption in Harris and Harper, 2004 that sweat lodge internal temperature is maintained at 150 °F.

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways* .

Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments* .

Cancer risk calculation

Radioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (pCi/L)	I_{inh} (radiological) (pCi)	SF_i[b] risk/pCi	Risk (unitless)	% Contribution
Americium-241	14596-10-2	--	0.13	5.51E+02	2.81E-08	1.55E-05	10
Carbon-14	14762-75-5	--	12	5.02E+04	7.07E-12	3.55E-07	0.24
Gross alpha	12587-46-1	--	6.2	2.61E+04	--	--	--
Plutonium-238	13981-16-3	--	0.24	9.96E+02	3.36E-08	3.34E-05	22
Plutonium-239/240	15117-48-3	--	0.70	2.95E+03	3.33E-08	9.84E-05	66
Strontium-90	10098-97-2	--	3.3	1.40E+04	1.05E-10	1.47E-06	0.98
Technetium-99	14133-76-7	--	6.1	2.59E+04	1.41E-11	3.65E-07	0.24
Tritium	10028-17-8	Yes	2,700	--(c)	5.62E-14	--	--
Total ELCR						1.50E-04	100

[a] Volatile radioactive contaminants as defined by EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

[b] EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

[c] Inhalation intake of volatile radionuclides in sweat lodge in presented in table C-7

-- = indicates radionuclide toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

EPA/540/R-92/003 *Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part B, Development of Preliminary Remediation Goals)* .

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

ATTACHMENT D

Attachment Table D-1. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment—Summary of Yakama Nation Sweat Lodge Exposure Scenario Noncancer Hazard Results for Radioactive and Nonradioactive Analytes in Groundwater (With Aerosolized Nonvolatile Analytes)

Nonradioactive Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (mg/L)	Volatile[a]	HQ (Inhalation) (Volatiles and Semi-Volatiles)	HQ (Inhalation) (Nonvolatiles)	HQ (Dermal, Vapor, Volatiles and Semi-Volatiles)	HQ (Dermal, Liquid, Nonvolatiles)	HQ (Dermal, Vapor, Nonvolatiles)	Total HQ	% Contribution
1,2-Dichloroethane	[illegible]	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
1,4-Dichlorobenzene	[illegible]	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
1,4-Dioxane	0.0076	Yes[b]	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Acetone	0.0018	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Aluminum	0.022	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Arsenic	0.0089	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	45
Barium	0.11	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	17
Boron	0.16	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Bromomethane	0.00051	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Chloride	37	—	—	—	—	—	—	—	—
Chlorobenzene	[illegible]	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Chloroform	[illegible]	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Chloromethane	[illegible]	Yes	[illegible]	—	—	—	—	[illegible]	[illegible]
Chromium	0.028	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]
Cobalt	0.00017	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Copper	0.0023	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]
Fluoride	0.52	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Hexavalent Chromium	0.030	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Iron	0.089	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]
Lead	[illegible]	—	—	—	—	—	—	—	—
Lithium	0.095	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]
Manganese	0.0080	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Molybdenum	0.0070	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]
Nickel	[illegible]	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Nitrate	110	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]
Selenium	0.0042	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Strontium	0.38	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]
Styrene	0.00014	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Sulfate	127	—	—	—	—	—	—	—	—
Tetrachloroethene	[illegible]	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Tin	[illegible]	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]
Toluene	0.000071	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Trichloroethene	0.011	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Trichloromonofluoromethane	0.00011	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Vanadium	0.017	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]
Xylenes (total)	[illegible]	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Zinc	[illegible]	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]
Total HI	—		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100

[a] Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles.
— = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.
HI = hazard index.
HQ = hazard quotient.
Harris and Harper 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.
Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment*.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment—Summary of Yakama Nation Sweat Lodge Exposure Scenario Cancer Risk Results for Nonradioactive Analytes in Groundwater (With Aerosolized Nonvolatile Analytes)

Nonradioactive Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (mg/L)	Volatile[a]	Risk (Inhalation) (Volatiles and Semi-Volatiles)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, Volatiles and Semi-Volatiles)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
1,2-Dichloroethane	[illegible]	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
1,4-Dichlorobenzene	0.00024	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
1,4-Dioxane	0.0076	Yes[b]	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Acetone	0.0018	Yes	—	—	—	—	—	—	—
Aluminum	0.022	—	—	—	—	—	—	—	—
Arsenic	0.0089	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Barium	0.11	—	—	—	—	—	—	—	—
Boron	0.16	—	—	—	—	—	—	—	—
Bromomethane	0.00051	Yes	—	—	—	—	—	—	—
Chloride	37	—	—	—	—	—	—	—	—
Chlorobenzene	0.00015	Yes	—	—	—	—	—	—	—
Chloroform	0.00045	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Chloromethane	0.000077	Yes	—	—	—	—	—	—	—
Chromium	0.028	—	—	—	—	—	—	—	—
Cobalt	0.00017	—	—	[illegible]	—	—	—	[illegible]	[illegible]
Copper	0.0023	—	—	—	—	—	—	—	—
Fluoride	0.52	—	—	—	—	—	—	—	—
Hexavalent Chromium	0.030	—	—	[illegible]	—	—	—	[illegible]	97
Iron	0.089	—	—	—	—	—	—	—	—
Lead	[illegible]	—	—	—	—	—	—	—	—
Lithium	0.095	—	—	—	—	—	—	—	—
Manganese	0.0080	—	—	—	—	—	—	—	—
Molybdenum	0.0070	—	—	—	—	—	—	—	—
Nickel	[illegible]	—	—	[illegible]	—	—	—	[illegible]	[illegible]
Nitrate	110	—	—	—	—	—	—	—	—
Selenium	0.0042	—	—	—	—	—	—	—	—
Strontium	0.38	—	—	—	—	—	—	—	—
Styrene	0.00014	Yes	—	—	—	—	—	—	—
Sulfate	127	—	—	—	—	—	—	—	—
Tetrachloroethene	[illegible]	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Tin	[illegible]	—	—	—	—	—	—	—	—
Toluene	0.000071	Yes	—	—	—	—	—	—	—
Trichloroethene	0.011	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Trichloromonofluoromethane	0.00011	Yes	—	—	—	—	—	—	—
Vanadium	0.017	—	—	—	—	—	—	—	—
Xylenes (total)	[illegible]	Yes	—	—	—	—	—	—	—
Zinc	[illegible]	—	—	—	—	—	—	—	—
Total ELCR			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100

[a] Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles.
— = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.
Harris and Harper 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.
Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment*.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment—Summary of Yakama Nations Sweat Lodge Exposure Scenario Cancer Risk Results for Radioactive Analytes in Groundwater (With Aerosolized Nonvolatile Analytes)

Radioactive Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (pCi/L)	Volatile[a]	Risk (Inhalation) (Volatiles and Semi-Volatiles)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, Volatiles and Semi-Volatiles)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
Americium-241	0.15		—	[illegible]	—	—	—	[illegible]	10
Carbon-14	12		—	[illegible]	—	—	—	[illegible]	0.13
Gross alpha	6.1		—	—	—	—	—	—	—
Plutonium-238	0.14		—	[illegible]	—	—	—	[illegible]	21
Plutonium-239/240	0.70		—	[illegible]	—	—	—	[illegible]	64
Strontium-90	3.3		—	[illegible]	—	—	—	[illegible]	[illegible]
Technetium-99	6.1		—	[illegible]	—	—	—	[illegible]	[illegible]
Tritium	2,700	Yes	[illegible]	—	—	—	—	[illegible]	2.4
Total ELCR			[illegible]	[illegible]	—	—	—	[illegible]	100

[a] Volatile radioactive contaminants as defined by EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."
— = indicates radionuclide toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment—Summary of Yakama Nations Sweat Lodge Exposure Scenario Cancer Risk Results for Radioactive and Nonradioactive Analytes in Groundwater (With Aerosolized Nonvolatile Analytes)

Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (mg/L or pCi/L)	Volatile[a]	Risk (Inhalation) (Volatiles and Semi-Volatiles)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, Volatiles and Semi-Volatiles)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
1,2-Dichloroethane	[illegible]	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
1,4-Dichlorobenzene	0.00024	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
1,4-Dioxane	0.0076	Yes[b]	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Acetone	0.0018	Yes	—	—	—	—	—	—	—
Aluminum	0.022	—	—	—	—	—	—	—	—
Arsenic	0.0089	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]
Barium	0.11	—	—	—	—	—	—	—	—
Boron	0.16	—	—	—	—	—	—	—	—
Bromomethane	0.00051	Yes	—	—	—	—	—	—	—
Chloride	37	—	—	—	—	—	—	—	—
Chlorobenzene	0.00015	Yes	—	—	—	—	—	—	—
Chloroform	0.00045	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Chloromethane	0.000077	Yes	—	—	—	—	—	—	—
Chromium	0.028	—	—	—	—	—	—	—	—
Cobalt	0.00017	—	—	[illegible]	—	—	—	[illegible]	[illegible]
Copper	0.0023	—	—	—	—	—	—	—	—
Fluoride	0.52	—	—	—	—	—	—	—	—
Hexavalent Chromium	0.030	—	—	[illegible]	—	—	—	[illegible]	96
Iron	0.089	—	—	—	—	—	—	—	—
Lead	[illegible]	—	—	—	—	—	—	—	—
Lithium	0.095	—	—	—	—	—	—	—	—
Manganese	0.0080	—	—	—	—	—	—	—	—
Molybdenum	0.0070	—	—	—	—	—	—	—	—
Nickel	[illegible]	—	—	[illegible]	—	—	—	[illegible]	[illegible]
Nitrate	110	—	—	—	—	—	—	—	—
Selenium	0.0042	—	—	—	—	—	—	—	—
Strontium	0.38	—	—	—	—	—	—	—	—
Styrene	0.00014	Yes	—	—	—	—	—	—	—
Sulfate	127	—	—	—	—	—	—	—	—
Tetrachloroethene	[illegible]	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Tin	[illegible]	—	—	—	—	—	—	—	—
Toluene	0.000071	Yes	—	—	—	—	—	—	—
Trichloroethene	0.011	Yes	[illegible]	—	[illegible]	—	—	[illegible]	[illegible]
Trichloromonofluoromethane	0.00011	Yes	—	—	—	—	—	—	—
Vanadium	0.017	—	—	—	—	—	—	—	—
Xylenes (total)	[illegible]	Yes	—	—	—	—	—	—	—
Zinc	[illegible]	—	—	—	—	—	—	—	—
Americium-241	0.15	—	—	[illegible]	—	—	—	[illegible]	0.11
Carbon-14	12	—	—	[illegible]	—	—	—	[illegible]	[illegible]
Gross alpha	6.1	—	—	—	—	—	—	—	—
Plutonium-238	0.24	—	—	[illegible]	—	—	—	[illegible]	0.24
Plutonium-239/240	0.70	—	—	[illegible]	—	—	—	[illegible]	0.71
Strontium-90	3.3	—	—	[illegible]	—	—	—	[illegible]	[illegible]
Technetium-99	6.1	—	—	[illegible]	—	—	—	[illegible]	[illegible]
Tritium	2,700	Yes	[illegible]	—	—	—	—	[illegible]	[illegible]
Total Cumulative ELCR			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100

[a] Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites" or as defined by EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."
[b] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles.
"—" = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.

Attachment Table D-2. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment—Summary of Yakama Nation Sweat Lodge Exposure Scenario Noncancer Hazard Results for Nonradioactive Analytes in Groundwater (Without Aerosolized Nonvolatile Analytes)

Nonradioactive Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (mg/L)	Volatile[a]	HQ (Inhalation) (Volatiles and Semi-Volatiles)	HQ (Inhalation) (Nonvolatiles)	HQ (Dermal, Vapor, Volatiles and Semi-Volatiles)	HQ (Dermal, Liquid, Nonvolatiles)	HQ (Dermal, Vapor, Nonvolatiles)	Total HQ	% Contribution
1,2-Dichloroethane	0.00010	Yes	5.17E-03	--	1.20E-07	--	--	5.17E-03	0.16
1,4-Dichlorobenzene	0.00018	Yes	1.08E-04	--	1.44E-07	--	--	1.08E-04	0.0034
1,4-Dioxane	0.0076	Yes[c]	8.17E-04	--	1.44E-07	--	--	8.17E-04	0.026
Acetone	0.0018	Yes	1.60E-05	--	1.28E-08	--	--	1.60E-05	0.0005
Aluminum	0.032	--	--	--(b)	--	4.01E-05	--(b)	4.01E-05	0.0013
Arsenic	0.0080	--	--	--(b)	--	5.37E-02	--(b)	5.37E-02	1.7
Barium	0.11	--	--	--(b)	--	1.41E-02	--(b)	1.41E-02	0.4
Boron	0.14	--	--	--(b)	--	1.22E-03	--(b)	1.22E-03	0.039
Bromomethane	0.00051	Yes	3.60E-02	--	1.74E-06	--	--	3.60E-02	1.1
Chloride	87	--	--	--	--	--	--	--	--
Chlorobenzene	0.00015	Yes	1.08E-03	--	8.61E-07	--	--	1.08E-03	0.034
Chloroform	0.00046	Yes	1.04E-03	--	3.12E-07	--	--	1.04E-03	0.033
Chloromethane	0.000077	Yes	5.10E-04	--	--	--	--	5.10E-04	0.016
Chromium	0.026	--	--	--	--	2.42E-03	--(b)	2.42E-03	0.076
Cobalt	0.00017	--	--	--(b)	--	4.15E-04	--(b)	4.15E-04	0.013
Copper	0.0023	--	--	--	--	1.06E-04	--(b)	1.06E-04	0.0033
Fluoride	0.52	--	--	--(b)	--	1.88E-02	--(b)	1.88E-02	0.60
Hexavalent Chromium	0.028	--	--	--(b)	--	9.62E-01	--(b)	9.62E-01	30
Iron	0.081	--	--	--	--	2.12E-04	--(b)	2.12E-04	0.0067
Lead	0.00030	--	--	--	--	--	--	--	--
Lithium	0.085	--	--	--	--	3.13E-02	--(b)	3.13E-02	1.0
Manganese	0.0088	--	--	--(b)	--	1.13E-02	--(b)	1.13E-02	0.35
Molybdenum	0.0079	--	--	--	--	2.85E-03	--(b)	2.85E-03	0.089
Nickel	0.0080	--	--	--(b)	--	2.25E-03	--(b)	2.25E-03	0.071
Nitrate	118	--	--	--	--	2.76E-02	--(b)	2.76E-02	0.87
Selenium	0.0041	--	--	--(b)	--	1.51E-03	--(b)	1.51E-03	0.048
Strontium	0.38	--	--	--	--	2.79E-03	--(b)	2.79E-03	0.088
Styrene	0.00014	Yes	4.88E-05	--	4.29E-09	--	--	4.88E-05	0.0015
Sulfate	127	--	--	--	--	--	--	--	--
Tetrachloroethene	0.00019	Yes	1.63E-03	--	1.70E-06	--	--	1.63E-03	0.051
Tin	0.00018	--	--	--	--	3.00E-07	--(b)	3.00E-07	0.0000094
Toluene	0.000072	Yes	5.31E-06	--	4.80E-09	--	--	5.31E-06	0.00017
Trichloroethene	0.011	Yes	1.98E+00	--	4.34E-04	--	--	1.98E+00	62
Trichloromonofluoromethane	0.00011	Yes	5.60E-05	--	8.19E-09	--	--	5.60E-05	0.0018
Vanadium	0.017	--	--	--	--	6.12E-03	--(b)	6.12E-03	0.19
Xylenes (total)	0.00080	Yes	7.24E-04	--	8.11E-08	--	--	7.24E-04	0.023
Zinc	0.0098	--	--	--	--	2.16E-05	--(b)	2.16E-05	0.00068
Total HI			2.04E+00	--(b)	4.50E-04	1.14E+00	--(b)	3.18E+00	100

[a] Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] The inhalation and dermal vapor contact exposure pathways are considered incomplete for nonvolatile contaminants.
[c] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.
HI = hazard index.
HQ = hazard quotient.
Harris and Harper 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.
Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment*.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment—Summary of Yakama Nation Sweat Lodge Exposure Scenario Cancer Risk Results for Nonradioactive Analytes in Groundwater (Without Aerosolized Nonvolatile Analytes)

Nonradioactive Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (mg/L)	Volatile[a]	Risk (Inhalation) (Volatiles and Semi-Volatiles)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, Volatiles and Semi-Volatiles)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
1,2-Dichloroethane	0.00010	Yes	9.41E-07	--	6.57E-11	--	--	9.41E-07	1.4
1,4-Dichlorobenzene	0.00024	Yes	9.36E-07	--	9.36E-11	--	--	9.36E-07	1.4
1,4-Dioxane	0.0076	Yes[c]	2.12E-05	--	4.81E-10	--	--	2.12E-05	31
Acetone	0.0018	Yes	--	--	--	--	--	--	--
Aluminum	0.032	--	--	--	--	--	--	--	--
Arsenic	0.0080	--	--	--(b)	--	2.42E-05	--(b)	2.42E-05	36
Barium	0.11	--	--	--	--	--	--	--	--
Boron	0.14	--	--	--	--	--	--	--	--
Bromomethane	0.00051	Yes	--	--	--	--	--	--	--
Chloride	87	--	--	--	--	--	--	--	--
Chlorobenzene	0.00015	Yes	--	--	--	--	--	--	--
Chloroform	0.00046	Yes	3.78E-06	--	1.65E-10	--	--	3.78E-06	5.6
Chloromethane	0.000077	Yes	--	--	--	--	--	--	--
Chromium	0.026	--	--	--	--	--	--	--	--
Cobalt	0.00017	--	--	--(b)	--	--	--	--	--
Copper	0.0023	--	--	--	--	--	--	--	--
Fluoride	0.52	--	--	--	--	--	--	--	--
Hexavalent Chromium	0.028	--	--	--(b)	--	--	--	--	--
Iron	0.081	--	--	--	--	--	--	--	--
Lead	0.00030	--	--	--	--	--	--	--	--
Lithium	0.085	--	--	--	--	--	--	--	--
Manganese	0.0088	--	--	--	--	--	--	--	--
Molybdenum	0.0079	--	--	--	--	--	--	--	--
Nickel	0.0080	--	--	--(b)	--	--	--	--	--
Nitrate	118	--	--	--	--	--	--	--	--
Selenium	0.0041	--	--	--	--	--	--	--	--
Strontium	0.38	--	--	--	--	--	--	--	--
Styrene	0.00014	Yes	--	--	--	--	--	--	--
Sulfate	127	--	--	--	--	--	--	--	--
Tetrachloroethene	0.00019	Yes	1.69E-08	--	2.14E-11	--	--	1.70E-08	0.025
Tin	0.00018	--	--	--	--	--	--	--	--
Toluene	0.000072	Yes	--	--	--	--	--	--	--
Trichloroethene	0.011	Yes	1.60E-05	--	1.04E-09	--	--	1.60E-05	24
Trichloromonofluoromethane	0.00011	Yes	--	--	--	--	--	--	--
Vanadium	0.017	--	--	--	--	--	--	--	--
Xylenes (total)	0.00080	Yes	--	--	--	--	--	--	--
Zinc	0.0098	--	--	--	--	--	--	--	--
Total ELCR			4.32E-05	--(b)	1.12E-09	2.42E-05	--(b)	6.74E-05	100

[a] Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] The inhalation and dermal vapor contact exposure pathways are considered incomplete for nonvolatile contaminants.
[c] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.
Harris and Harper 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*.
Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment*.

100-FR-3 Groundwater Operable Unit Native American Risk Assessment—Summary of Yakama Nations Sweat Lodge Exposure Scenario Cancer Risk Results for Radioactive Analytes in Groundwater (Without Aerosolized Nonvolatile Analytes)

Radioactive Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (pCi/L)	Volatile[a]	Risk (Inhalation) (Volatiles and Semi-Volatiles)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, Volatiles and Semi-Volatiles)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
Americium-241	0.10		--	--(b)	--	--	--	--	--
Carbon-14	12		--	--(b)	--	--	--	--	--
Gross alpha	8.2		--	--	--	--	--	--	--
Plutonium-238	0.24		--	--(b)	--	--	--	--	--
Plutonium-239/240	0.78		--	--(b)	--	--	--	--	--
Strontium-90	8.5		--	--(b)	--	--	--	--	--
Technetium-99	6.1		--	--(b)	--	--	--	--	--
Tritium	2,700	Yes	2.81E-05	--	--	--	--	2.81E-05	100
Total ELCR			2.81E-05	--(b)	--	--	--	2.81E-05	100

[a] Volatile radioactive contaminants as defined by EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."
[b] The inhalation and dermal vapor contact exposure pathways are considered incomplete for nonvolatile contaminants.
-- = indicates radionuclide toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*

100-FR-3 Groundwater Operable Unit Native American Risk Assessment—Summary of Yakama Nations Sweat Lodge Exposure Scenario Cancer Risk Results for Radioactive and Nonradioactive Analytes in Groundwater (Without Aerosolized Nonvolatile Analytes)

Analyte Name	90th Percentile Concentration in Groundwater C_{gw} (mg/L or pCi/L)	Volatile[a]	Risk (Inhalation) (Volatiles and Semi-Volatiles)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, Volatiles and Semi-Volatiles)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
1,2-Dichloroethane	0.00010	Yes	9.41E-07	--	6.57E-11	--	--	9.41E-07	0.99
1,4-Dichlorobenzene	0.00024	Yes	9.36E-07	--	9.36E-11	--	--	9.36E-07	1.0
1,4-Dioxane	0.0076	Yes[c]	2.12E-05	--	4.81E-10	--	--	2.12E-05	22
Acetone	0.0018	Yes	--	--	--	--	--	--	--
Aluminum	0.032	--	--	--	--	--	--	--	--
Arsenic	0.0080	--	--	--(b)	--	2.42E-05	--(b)	2.42E-05	25
Barium	0.11	--	--	--	--	--	--	--	--
Boron	0.14	--	--	--	--	--	--	--	--
Bromomethane	0.00051	Yes	--	--	--	--	--	--	--
Chloride	87	--	--	--	--	--	--	--	--
Chlorobenzene	0.00015	Yes	--	--	--	--	--	--	--
Chloroform	0.00046	Yes	3.78E-06	--	1.65E-10	--	--	3.78E-06	4.0
Chloromethane	0.000077	Yes	--	--	--	--	--	--	--
Chromium	0.026	--	--	--	--	--	--	--	--
Cobalt	0.00017	--	--	--(b)	--	--	--	--	--
Copper	0.0023	--	--	--	--	--	--	--	--
Fluoride	0.52	--	--	--	--	--	--	--	--
Hexavalent Chromium	0.028	--	--	--(b)	--	--	--	--	--
Iron	0.080	--	--	--	--	--	--	--	--
Lead	0.00030	--	--	--	--	--	--	--	--
Lithium	0.085	--	--	--	--	--	--	--	--
Manganese	0.0088	--	--	--	--	--	--	--	--
Molybdenum	0.0079	--	--	--	--	--	--	--	--
Nickel	0.0080	--	--	--(b)	--	--	--	--	--
Nitrate	118	--	--	--	--	--	--	--	--
Selenium	0.0041	--	--	--	--	--	--	--	--
Strontium	0.38	--	--	--	--	--	--	--	--
Styrene	0.00014	Yes	--	--	--	--	--	--	--
Sulfate	127	--	--	--	--	--	--	--	--
Tetrachloroethene	0.00019	Yes	1.69E-08	--	2.14E-11	--	--	1.70E-08	0.018
Tin	0.00018	--	--	--	--	--	--	--	--
Toluene	0.000072	Yes	--	--	--	--	--	--	--
Trichloroethene	0.011	Yes	1.60E-05	--	1.04E-09	--	--	1.60E-05	17
Trichloromonofluoromethane	0.00011	Yes	--	--	--	--	--	--	--
Vanadium	0.017	--	--	--	--	--	--	--	--
Xylenes (total)	0.00080	Yes	--	--	--	--	--	--	--
Zinc	0.0098	--	--	--	--	--	--	--	--
Americium-241	0.10	--	--	--(b)	--	--	--	--	--
Carbon-14	12	--	--	--(b)	--	--	--	--	--
Gross alpha	8.2	--	--	--	--	--	--	--	--
Plutonium-238	0.24	--	--	--(b)	--	--	--	--	--
Plutonium-239/240	0.78	--	--	--(b)	--	--	--	--	--
Strontium-90	8.5	--	--	--(b)	--	--	--	--	--
Technetium-99	6.1	--	--	--(b)	--	--	--	--	--
Tritium	2,700	Yes	2.81E-05	--	--	--	--	2.81E-05	29
Total Cumulative ELCR			7.13E-05	--(b)	1.12E-09	2.42E-05	--(b)	9.55E-05	100

[a] Volatile contaminants as defined by EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites" or as defined by EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."
[b] The inhalation and dermal vapor contact exposure pathways are considered incomplete for nonvolatile contaminants.
[c] Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.

Attachment Table D-3. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment
Hazard quotient and cancer risk from inhalation of volatiles and semi-volatiles in sweat lodge vapor
Yakama Nation Sweat lodge Scenario (Ridolfi, 2007)

Yakama Nation exposure scenario (Ridolfi, 2007) does not include a model for estimating contaminant concentrations in sweat lodge air from contaminant concentrations in groundwater used to make steam. Evaluation performed using steam model from CTUIR sweat lodge scenario (Harris and Harper, 2004).

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Inhalation Intake of Analytes - Volatiles and Semi-Volatiles	I_{inh}	Calculated Value	mg/kg-day	Equation 30
Groundwater Concentration	C_{dw}	Analyte- specific	mg/L	ECF-100FR3-11-0024
Cumulative Volume of water used in a sweat	$V_{a\,total}$	4	L	Harris and Harper, 2004
Radius of Sweat Lodge	r	1	m	Harris and Harper, 2004
Inhalation Rate- adult	IR	26	m^3/day	Ridolfi, 2007
Length of Sweat Event- adult[a]	ET	0.292	7/24 days/event	Ridolfi, 2007
Exposure Frequency or Number of Sweats per Year	EF	365	events/year	Harris and Harper, 2004
Exposure Duration or number of years a person sweats in a lifetime - adult	ED	70	years	Harris and Harper, 2004
Average body weight - adult	BW	70	kg	Harris and Harper, 2004
Averaging Time (noncarcinogens)[b]	AT	70	years	Harris and Harper, 2004
Averaging Time (carcinogens)[b]	AT	70	years	Harris and Harper, 2004
The constant pi	π	3.14159	unitless	--
Inhalation Reference Concentration	RfC	Analyte-specific	mg/m^3	EPA, 2012
Inhalation Reference Dose	RfD_i	Calculated Value	mg/kg-day	Equation 51
Inhalation Unit Risk	IUR	Analyte-specific	$(\mu g/m^3)^{-1}$	EPA, 2012
Inhalation Cancer Slope Factor	CSF_i	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	Equation 50
Conversion Factor	CF1	365	days/year	1 year = 365 days

[a] For sweat lodge inhalation exposure, exposure time of 7 hr was replaced with 7/24 days/event so that the intake values have appropriate units.(mg/kg-day or pCi) when calculated using the inhalation equations provided in Harris and Harper, 2004

[b]Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for both carcinogens and noncarcinogens to account for lifetime intake rather than annual intake.

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*
EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways* .
Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment* .

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	I_{inh}(noncarcinogen) (mg/kg-day)	RfC[a] (mg/m^3)	RfD_i[b] (mg/kg-day)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	1.03E-05	7.00E-03	2.00E-03	5.17E-03	0.25
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	2.48E-05	8.00E-01	2.29E-01	1.09E-04	0.0053
1,4-Dioxane	123-91-1	Yes[d]	0.0076	7.84E-04	3.00E+00	8.57E-01	9.17E-04	0.043
Acetone	67-64-1	Yes	0.0013	1.33E-04	3.10E+01	8.86E+00	1.50E-05	0.00074
Aluminum	7429-90-5	--	0.022	--(a)	5.00E-03	1.43E-03	--	--
Arsenic	7440-38-2	--	0.0090	--(a)	1.50E-05	4.29E-06	--	--
Barium	7440-39-3	--	0.11	--(a)	5.00E-04	1.43E-04	--	--
Boron	7440-42-8	--	0.14	--(a)	2.00E-02	5.71E-03	--	--
Bromomethane	74-83-9	Yes	0.00051	5.22E-05	5.00E-03	1.43E-03	3.65E-02	1.8
Chloride	16887-00-6	--	37	--(c)	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	1.55E-05	5.00E-02	1.43E-02	1.08E-03	0.053
Chloroform	67-66-3	Yes	0.00046	4.71E-05	9.80E-02	2.80E-02	1.68E-03	0.082
Chloromethane	74-87-3	Yes	0.000077	7.97E-06	9.00E-02	2.57E-02	3.10E-04	0.015
Chromium	7440-47-3	--	0.026	--(a)	--	--	--	--
Cobalt	7440-48-4	--	0.00017	--(a)	6.00E-06	1.71E-06	--	--
Copper	7440-50-8	--	0.0023	--(a)	--	--	--	--
Fluoride	16984-48-8	--	0.52	--(a)	1.30E-02	3.71E-03	--	--
Hexavalent Chromium	18540-29-9	--	0.020	--(a)	1.00E-04	2.86E-05	--	--
Iron	7439-89-6	--	0.083	--(a)	--	--	--	--
Lead	7439-92-1	--	0.00020	--(a)	--	--	--	--
Lithium	7439-93-2	--	0.035	--(a)	--	--	--	--
Manganese	7439-96-5	--	0.0080	--(a)	5.00E-05	1.43E-05	--	--
Molybdenum	7439-98-7	--	0.0079	--(a)	--	--	--	--
Nickel	7440-02-0	--	0.0050	--(a)	9.00E-05	2.57E-05	--	--
Nitrate	14797-55-8	--	110	--(a)	--	--	--	--
Selenium	7782-49-2	--	0.0042	--(a)	2.00E-02	5.71E-03	--	--
Strontium	7440-24-6	--	0.93	--(a)	--	--	--	--
Styrene	100-42-5	Yes	0.00014	1.40E-05	1.00E+00	2.86E-01	4.89E-05	0.0024
Sulfate	14808-79-8	--	127	--(c)	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	1.88E-05	4.00E-02	1.14E-02	1.65E-03	0.080
Tin	7440-31-5	--	0.00010	--(c)	--	--	--	--
Toluene	108-88-3	Yes	0.000072	7.46E-06	5.00E+00	1.43E+00	5.21E-06	0.00026
Trichloroethene	79-01-6	Yes	0.011	1.14E-03	2.00E-05	5.71E-04	1.99E+00	98
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.14E-05	7.00E-01	2.00E-01	5.69E-05	0.0028
Vanadium	7440-62-2	--	0.017	--(c)	--	--	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	2.07E-05	1.00E-01	2.86E-02	7.24E-04	0.036
Zinc	7440-66-6	--	0.0060	--(c)	--	--	--	--
Total HI							2.04E+00	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] Inhalation reference concentration (RfC) converted to inhalation reference dose (RfD) following EPA protocol (EPA 540/1-89/002) using formula RfD_i (mg/kg-day) = RfC (mg/m^3) x 20 (m^3/day) x 1/70 (kg).
[c] Inhalation intake of nonvolatiles is presented in table D-4
[d]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.
EPA 540/1-89/002 *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A).*
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*
HQ = hazard quotient.

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	I_{inh}(carcinogen) (mg/kg-day)	IUR[a] $(\mu g/m^3)^{-1}$	CSF_i[b] $(mg/kg\text{-}day)^{-1}$	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	1.03E-05	2.60E-05	9.10E-02	9.41E-07	2.2
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	2.48E-05	1.10E-05	3.85E-02	9.56E-07	2.2
1,4-Dioxane	123-91-1	Yes[d]	0.0076	7.84E-04	7.70E-06	2.70E-02	2.12E-05	49
Acetone	67-64-1	Yes	0.0013	1.33E-04	--	--	--	--
Aluminum	7429-90-5	--	0.022	--(c)	--	--	--	--
Arsenic	7440-38-2	--	0.0090	--(c)	4.30E-03	1.51E+01	--	--
Barium	7440-39-3	--	0.11	--(a)	--	--	--	--
Boron	7440-42-8	--	0.14	--(c)	--	--	--	--
Bromomethane	74-83-9	Yes	0.00051	5.22E-05	--	--	--	--
Chloride	16887-00-6	--	37	--(c)	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	1.55E-05	--	--	--	--
Chloroform	67-66-3	Yes	0.00046	4.71E-05	2.30E-05	8.05E-02	3.79E-06	8.8
Chloromethane	74-87-3	Yes	0.000077	7.97E-06	--	--	--	--
Chromium	7440-47-3	--	0.026	--(a)	--	--	--	--
Cobalt	7440-48-4	--	0.00017	--(a)	9.00E-03	3.15E+01	--	--
Copper	7440-50-8	--	0.0023	--(a)	--	--	--	--
Fluoride	16984-48-8	--	0.52	--(a)	--	--	--	--
Hexavalent Chromium	18540-29-9	--	0.020	--(a)	8.90E-02	2.94E+02	--	--
Iron	7439-89-6	--	0.083	--(c)	--	--	--	--
Lead	7439-92-1	--	0.00020	--(a)	--	--	--	--
Lithium	7439-93-2	--	0.035	--(a)	--	--	--	--
Manganese	7439-96-5	--	0.0080	--(c)	--	--	--	--
Molybdenum	7439-98-7	--	0.0079	--(a)	--	--	--	--
Nickel	7440-02-0	--	0.0050	--(a)	2.60E-04	9.10E-01	--	--
Nitrate	14797-55-8	--	110	--(a)	--	--	--	--
Selenium	7782-49-2	--	0.0042	--(a)	--	--	--	--
Strontium	7440-24-6	--	0.93	--(a)	--	--	--	--
Styrene	100-42-5	Yes	0.00014	1.40E-05	--	--	--	--
Sulfate	14808-79-8	--	127	--(c)	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	1.88E-05	2.60E-07	9.10E-04	1.69E-08	0.039
Tin	7440-31-5	--	0.00010	--(c)	--	--	--	--
Toluene	108-88-3	Yes	0.000072	7.46E-06	--	--	--	--
Trichloroethene	79-01-6	Yes	0.011	1.14E-03	4.10E-06	1.44E-02	1.63E-05	38
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.14E-05	--	--	--	--
Vanadium	7440-62-2	--	0.017	--(c)	--	--	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	2.07E-05	--	--	--	--
Zinc	7440-66-6	--	0.0060	--(c)	--	--	--	--
Total ELCR							4.32E-05	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] Inhalation unit risk (IUR) converted to inhalation cancer slope factor (CSF) following EPA protocol (EPA 540/1-89/002) using formula CSF_i (kg-day/mg) = IUR (m^3/kg) x 1/20 (m^3/day) x 70 (kg) x 1000 (µg/mg).
[c] Inhalation intake of nonvolatiles is presented in table D-4
[d]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.
EPA 540/1-89/002 *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A).*
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*

Attachment Table D-4. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment
Hazard quotient and cancer risk from inhalation of nonvolatiles in sweat lodge vapor
Yakama Nation Sweat Lodge Scenario (Ridolfi, 2007)

Yakama Nation exposure scenario (Ridolfi, 2007) does not include a model for estimating contaminant concentrations in sweat lodge air from contaminant concentrations in groundwater used to make steam. Evaluation performed using steam model from CTUIR sweat lodge scenario (Harris and Harper, 2004).

Intake Parameter Values				
Parameter	Symbol	Value	Unit	Source
Inhalation Intake of Analytes - Nonvolatiles	I_{inh}	Calculated Value	mg/kg-day	Equation 35
Groundwater Concentration	C_{dw}	Analyte- specific	mg/L	ECF-100FR3-11-0024
Temperature inside of the sweat lodge[a]	T	338.7	K	Harris and Harper, 2004
Ideal gas law constant	R	0.06237	(mmHg-m^3)/(gmole-K)	Harris and Harper, 2004
Inhalation rate- adult	IR	26	m^3/day	Ridolfi, 2007
Length of sweat event - adult[b]	ET	0.292	7/24 days/event	Ridolfi, 2007
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	70	years	Harris and Harper, 2004
Average body weight - adult	BW	70	kg	Harris and Harper, 2004
Averaging time (noncarcinogens)[c]	AT	70	years	Harris and Harper, 2004
Averaging time (carcinogens)[c]	AT	70	years	Harris and Harper, 2004
Inhalation Reference Concentration	RfC	Analyte-specific	mg/m^3	EPA, 2012
Inhalation Reference Dose	RfD_i	Calculated Value	mg/kg-day	Equation 51
Inhalation Unit Risk	IUR	Analyte-specific	(µg/m^3)$^{-1}$	EPA, 2012
Inhalation Cancer Slope Factor	CSF_i	Analyte-specific	(mg/kg-day)$^{-1}$	Equation 50
Conversion Factor	CF1	365	days/year	1 year = 365 days
Molecular weight of water	MW_w	18	g/mole	Harris and Harper, 2004
Density of liquid water	ρ_w	1000	g/L	Harris and Harper, 2004

[a]Temperature of 389 K provided in Harris and Harper, 2004 was replaced with 338.7 K (150 °F) for consistency with stated assumption in Harris and Harper, 2004 that sweat lodge internal temperature is maintained at 150 °F.

[b] For sweat lodge inhalation exposure, exposure time of 7 hr was replaced with 7/24 days/event so that the intake values have appropriate units (mg/kg-day or pCi) when calculated using the inhalation equations provided in Harris and Harper, 2004

[c] Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for both carcinogens and noncarcinogens to account for lifetime intake rather than annual intake

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*
EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*
Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment.*

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	I_{inh}(noncarcinogen) (mg/kg-day)	RfC[a] (mg/m^3)	RfD_i[b] (mg/kg-day)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	--(c)	7.00E-03	2.00E-03	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	--(c)	8.00E-01	2.29E-01	--	--
1,4-Dioxane	123-91-1	Yes[d]	0.0076	--(c)	3.00E+00	8.57E-01	--	--
Acetone	67-64-1	Yes	0.0013	--(c)	3.10E+01	8.86E+00	--	--
Aluminum	7429-90-5	--	0.022	3.85E-04	5.00E-03	1.43E-03	2.70E-01	0.35
Arsenic	7440-38-2	--	0.0090	1.59E-04	1.50E-05	4.29E-06	3.71E+01	47
Barium	7440-39-3	--	0.11	1.95E-03	5.00E-04	1.43E-04	1.37E+01	17
Boron	7440-42-8	--	0.14	2.41E-03	2.00E-02	5.71E-03	4.22E-01	0.53
Bromomethane	74-83-9	Yes	0.00051	--(c)	5.00E-03	1.43E-03	--	--
Chloride	16887-00-6	--	37	6.50E-01	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	--(c)	5.00E-02	1.43E-02	--	--
Chloroform	67-66-3	Yes	0.00046	--(c)	9.80E-02	2.80E-02	--	--
Chloromethane	74-87-3	Yes	0.000077	--(c)	9.00E-02	2.57E-02	--	--
Chromium	7440-47-3	--	0.028	4.88E-04	--	--	--	--
Cobalt	7440-48-4	--	0.00017	3.07E-06	6.00E-06	1.71E-06	1.79E+00	2.3
Copper	7440-50-8	--	0.0023	4.16E-05	--	--	--	--
Fluoride	16984-48-8	--	0.52	9.22E-03	1.30E-02	3.71E-03	2.48E+00	3.1
Hexavalent Chromium	18540-29-9	--	0.020	3.56E-04	1.00E-04	2.86E-05	1.25E+01	16
Iron	7439-89-6	--	0.083	1.46E-03	--	--	--	--
Lead	7439-92-1	--	0.00020	3.55E-06	--	--	--	--
Lithium	7439-93-2	--	0.035	6.21E-04	--	--	--	--
Manganese	7439-96-5	--	0.0060	1.07E-04	5.00E-05	1.43E-05	7.48E+00	9.4
Molybdenum	7439-98-7	--	0.0079	1.41E-04	--	--	--	--
Nickel	7440-02-0	--	0.0050	8.88E-05	9.00E-05	2.57E-05	3.45E+00	4.4
Nitrate	14797-55-8	--	110	1.94E+00	--	--	--	--
Selenium	7782-49-2	--	0.0042	7.46E-05	2.00E-02	5.71E-03	1.31E-02	0.017
Strontium	7440-24-6	--	0.93	1.65E-02	--	--	--	--
Styrene	100-42-5	Yes	0.00014	--(c)	1.00E+00	2.86E-01	--	--
Sulfate	14808-79-8	--	127	2.25E+00	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00016	--(c)	4.00E-02	1.14E-02	--	--
Tin	7440-31-5	--	0.00010	1.78E-06	--	--	--	--
Toluene	108-88-3	Yes	0.000072	--(c)	5.00E+00	1.43E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	--(c)	2.00E-03	5.71E-04	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	--(c)	7.00E-01	2.00E-01	--	--
Vanadium	7440-62-2	--	0.017	3.02E-04	--	--	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	--(c)	1.00E-01	2.86E-02	--	--
Zinc	7440-66-6	--	0.0060	1.07E-04	--	--	--	--
Total HI							7.91E+01	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] Inhalation reference concentration (RfC) converted to inhalation reference dose (RfD_i) following EPA protocol (EPA 540/1-89/002) using formula RfD_i (mg/kg-day) = RfC (mg/m^3) x 20 (m^3/day) x 1/70 (kg).
[c] Inhalation of volatile compounds in vapor is presented in Table D-3
[d]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.
HI= hazard index.
HQ = hazard quotient.
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	I_{inh}(carcinogen) (mg/kg-day)	IUR[a] (µg/m^3)$^{-1}$	CSF_i[b] (mg/kg-day)$^{-1}$	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	--(c)	2.60E-05	9.10E-02	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	--(c)	1.10E-05	3.85E-02	--	--
1,4-Dioxane	123-91-1	Yes[d]	0.0076	--(c)	7.70E-06	2.70E-02	--	--
Acetone	67-64-1	Yes	0.0013	--(c)	--	--	--	--
Aluminum	7429-90-5	--	0.022	3.85E-04	--	--	--	--
Arsenic	7440-38-2	--	0.0090	1.59E-04	4.30E-03	1.51E+01	2.39E-03	2.3
Barium	7440-39-3	--	0.11	1.95E-03	--	--	--	--
Boron	7440-42-8	--	0.14	2.41E-03	--	--	--	--
Bromomethane	74-83-9	Yes	0.00051	--(c)	--	--	--	--
Chloride	16887-00-6	--	37	6.50E-01	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	--(c)	--	--	--	--
Chloroform	67-66-3	Yes	0.00046	--(c)	2.30E-05	8.05E-02	--	--
Chloromethane	74-87-3	Yes	0.000077	--(c)	--	--	--	--
Chromium	7440-47-3	--	0.028	4.88E-04	--	--	--	--
Cobalt	7440-48-4	--	0.00017	3.07E-06	9.00E-03	3.15E+01	9.67E-05	0.085
Copper	7440-50-8	--	0.0023	4.16E-05	--	--	--	--
Fluoride	16984-48-8	--	0.52	9.22E-05	--	--	--	--
Hexavalent Chromium	18540-29-9	--	0.020	3.56E-04	8.40E-02	2.94E+02	8.93E-02	97
Iron	7439-89-6	--	0.083	1.46E-03	--	--	--	--
Lead	7439-92-1	--	0.00020	3.55E-06	--	--	--	--
Lithium	7439-93-2	--	0.035	6.21E-04	--	--	--	--
Manganese	7439-96-5	--	0.0060	1.07E-04	--	--	--	--
Molybdenum	7439-98-7	--	0.0079	1.41E-04	--	--	--	--
Nickel	7440-02-0	--	0.0050	8.88E-05	2.60E-04	9.10E-01	8.08E-05	0.079
Nitrate	14797-55-8	--	110	1.94E+00	--	--	--	--
Selenium	7782-49-2	--	0.0042	7.46E-05	--	--	--	--
Strontium	7440-24-6	--	0.93	1.65E-02	--	--	--	--
Styrene	100-42-5	Yes	0.00014	--(c)	--	--	--	--
Sulfate	14808-79-8	--	127	2.25E+00	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00016	--(c)	2.60E-07	9.10E-04	--	--
Tin	7440-31-5	--	0.00010	1.78E-06	--	--	--	--
Toluene	108-88-3	Yes	0.000072	--(c)	--	--	--	--
Trichloroethene	79-01-6	Yes	0.011	--(c)	4.10E-06	1.44E-02	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	--(c)	--	--	--	--
Vanadium	7440-62-2	--	0.017	3.02E-04	--	--	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	--(c)	--	--	--	--
Zinc	7440-66-6	--	0.0060	1.07E-04	--	--	--	--
Total ELCR							1.02E-01	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] Inhalation unit risk (IUR) converted to inhalation cancer slope factor (CSF_i) following EPA protocol (EPA 540/1-89/002) using formula CSF_i (kg-day/mg) = IUR (m^3/µg) x 1/20 (m^3/day) x 70 (kg) x 1000 (µg/mg).
[c] Inhalation of volatile compounds in vapor is presented in Table D-3
[d]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*

Attachment Table D-5. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment
Hazard quotient and cancer risk from dermal exposure to volatiles and semi-volatiles in sweat lodge vapor
Yakama Nation Sweat Lodge Scenario (Ridolfi, 2007)

Yakama Nation exposure scenario (Ridolfi, 2007) does not include a model for estimating contaminant concentrations in sweat lodge air from contaminant concentrations in groundwater used to make steam. Evaluation performed using steam model from CTUIR sweat lodge scenario (Harris and Harper 2004).

Model assumes 100% volatilization of volatiles and semi-volatiles; hence, dermal intake from volatiles and semi-volatiles in condensed water ($I_{d,v}$) can be neglected and total dermal intake (Id,total) is equal to dermal intake from volatiles and semi-volatiles in sweat lodge vapor (Id,v)

Parameter	Symbol	Value	Unit	Source
Dermal Intake of Analytes - Volatile Vapor (Id,total = Id,v)	$I_{d,vapor}$	Calculated Value	mg/kg-day	Equation 40
Groundwater Concentration	C_{gw}	Analyte- specific	mg/L	ECF-100FR3-11-0024
Cumulative Volume of water used in a sweat	$V_{w,total}$	4	L	Harris and Harper, 2004
Radius of Sweat Lodge	r	1	m	Harris and Harper, 2004
Skin Surface Area - adult	SA	1.8	m^2	Harris and Harper, 2004
Analyte-specific permeability constant	K_p	Analyte- specific	cm/hour	EPA/540/R/99/005
Length of sweat event - adult	ET	7	hours/event	Ridolfi, 2007
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	70	years	Harris and Harper, 2004
Average body weight - adult	BW	70	kg	Harris and Harper, 2004
Averaging time (noncarcinogens)[a]	AT	70	years	Harris and Harper, 2004
Averaging time (carcinogens)[a]	AT	70	years	Harris and Harper, 2004
The constant pi	π	3.14159	unitless	--
Reference Dose - Oral	RfD_o	Analyte-specific	mg/kg-day	EPA, 2012
Gastrointestinal Absorption Factor	GIABS	Analyte-specific	unitless	EPA, 2012
Cancer Slope Factor - Oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	EPA, 2012
Conversion factor	CF1	365	days/year	1 year = 365 days
Conversion factor	CF2	0.01	m/cm	1 m = 100 cm

[a]Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for both carcinogens and noncarcinogens to account for lifetime intake rather than annual intake

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistance Lifeways .*
Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment .*

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[c]	C_{gw} (mg/L)	K_p[b] (cm/hr)	$I_{d,vapor}$(noncarcinogen) (mg/kg-day)	RfD_o[a] (mg/kg-day)	GIABS[a] (unitless)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	7.22E-10	6.00E-03	1.00E+00	1.20E-07	0.026
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	4.20E-02	1.73E-08	7.00E-03	1.00E+00	2.48E-07	0.054
1,4-Dioxane	123-91-1	Yes[d]	0.0079	3.30E-04	4.31E-09	3.00E-02	1.00E+00	1.44E-07	0.031
Acetone[d]	67-64-1	Yes	0.0013	5.12E-04	1.13E-09	9.00E-01	1.00E+00	1.26E-09	0.00027
Aluminum	7429-90-5	--	0.022	1.00E-03	--[c]	1.00E+00	1.00E+00	--	--
Arsenic	7440-38-2	--	0.0080	1.00E-03	--[c]	3.00E-04	1.00E+00	--	--
Barium	7440-39-3	--	0.11	1.00E-03	--[c]	2.00E-01	7.00E-02	--	--
Boron	7440-42-8	--	0.14	1.00E-03	--[c]	2.00E-01	1.00E+00	--	--
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	2.43E-09	1.40E-03	1.00E+00	1.74E-03	0.38
Chloride	16887-00-6	--	37	1.00E-03	--[c]	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	7.22E-09	2.00E-02	1.00E+00	3.61E-07	0.079
Chloroform	67-66-3	Yes	0.00046	6.80E-03	5.32E-09	1.00E-02	1.00E+00	5.32E-07	0.12
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	4.37E-10	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	--[c]	1.50E+00	1.30E-02	--	--
Cobalt	7440-48-4	--	0.00017	4.00E-04	--[c]	3.00E-04	1.00E+00	--	--
Copper	7440-50-8	--	0.0023	1.00E-03	--[c]	4.00E-02	1.00E+00	--	--
Fluoride	16984-48-8	--	0.52	1.00E-03	--[c]	6.00E-02	1.00E+00	--	--
Hexavalent Chromium	18540-29-9	--	0.020	2.00E-03	--[c]	3.00E-03	2.50E-02	--	--
Iron	7439-89-6	--	0.083	1.00E-03	--[c]	7.00E-01	1.00E+00	--	--
Lead	7439-92-1	--	0.00020	1.00E-04	--[c]	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	--[c]	2.00E-03	1.00E+00	--	--
Manganese	7439-96-5	--	0.0060	1.00E-03	--[c]	2.40E-02	4.00E-02	--	--
Molybdenum	7439-98-7	--	0.0079	1.00E-03	--[c]	5.00E-03	1.00E+00	--	--
Nickel	7440-02-0	--	0.0050	2.00E-04	--[c]	2.00E-02	4.00E-02	--	--
Nitrate	14797-55-8	--	110	1.00E-03	--[c]	7.10E+00	1.00E+00	--	--
Selenium	7782-49-2	--	0.0042	1.00E-03	--[c]	5.00E-03	1.00E+00	--	--
Strontium	7440-24-6	--	0.93	1.00E-03	--[c]	6.00E-01	1.00E+00	--	--
Styrene	100-42-5	Yes	0.00014	3.70E-02	8.98E-09	2.00E-01	1.00E+00	4.29E-08	0.0094
Sulfate	14808-79-8	--	127	1.00E-03	--[c]	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	3.30E-02	1.02E-08	6.00E-03	1.00E+00	1.70E-06	0.37
Tin	7440-31-5	--	0.00010	1.00E-03	--[c]	6.00E-01	1.00E+00	--	--
Toluene	108-88-3	Yes	0.000072	3.10E-02	3.84E-09	8.00E-02	1.00E+00	4.80E-08	0.010
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	2.27E-07	5.00E-04	1.00E+00	4.54E-04	99
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	2.46E-09	3.00E-01	1.00E+00	8.19E-09	0.0018
Vanadium	7440-62-2	--	0.017	1.00E-03	--[c]	5.00E-03	1.00E+00	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	1.82E-08	2.00E-01	1.00E+00	9.11E-08	0.020
Zinc	7440-66-6	--	0.0060	6.00E-04	--[c]	3.00E-01	1.00E+00	--	--
Total HI								4.59E-04	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics)
[c] Dermal intake of nonvolatiles in sweat lodge vapor is presented in Table D-7
[d]K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).
[c]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.
HI = hazard index.
HQ = hazard quotient.
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistance Lifeways*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[c]	C_{gw} (mg/L)	K_p[b] (cm/hr)	$I_{d,vapor}$(carcinogen) (mg/kg-day)	CSF_o[a] $(mg/kg\text{-}day)^{-1}$	GIABS[a] (unitless)	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	7.22E-10	9.10E-02	1.00E+00	6.57E-11	0.59
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	4.20E-02	1.73E-08	5.40E-08	1.00E+00	9.36E-11	0.83
1,4-Dioxane	123-91-1	Yes[d]	0.0076	3.30E-04	4.31E-09	1.00E-01	1.00E+00	4.31E-10	3.8
Acetone[d]	67-64-1	Yes	0.0013	5.12E-04	1.13E-09	--	1.00E+00	--	--
Aluminum	7429-90-5	--	0.022	1.00E-03	--[c]	--	1.00E+00	--	--
Arsenic	7440-38-2	--	0.0080	1.00E-03	--[c]	1.50E+00	1.00E+00	--	--
Barium	7440-39-3	--	0.11	1.00E-03	--[c]	--	7.00E-02	--	--
Boron	7440-42-8	--	0.14	1.00E-03	--[c]	--	1.00E+00	--	--
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	2.43E-09	--	1.00E+00	--	--
Chloride	16887-00-6	--	37	1.00E-03	--[c]	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	7.22E-09	--	1.00E+00	--	--
Chloroform	67-66-3	Yes	0.00046	6.80E-03	5.32E-09	3.10E-02	1.00E+00	1.65E-10	1.5
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	4.37E-10	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	--[c]	--	1.30E-02	--	--
Cobalt	7440-48-4	--	0.00017	4.00E-04	--[c]	--	1.00E+00	--	--
Copper	7440-50-8	--	0.0023	1.00E-03	--[c]	--	1.00E+00	--	--
Fluoride	16984-48-8	--	0.52	1.00E-03	--[c]	--	1.00E+00	--	--
Hexavalent Chromium	18540-29-9	--	0.020	2.00E-03	--[c]	--	2.50E-02	--	--
Iron	7439-89-6	--	0.083	1.00E-03	--[c]	--	1.00E+00	--	--
Lead	7439-92-1	--	0.00020	1.00E-04	--[c]	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	--[c]	--	1.00E+00	--	--
Manganese	7439-96-5	--	0.0060	2.00E-03	--[c]	--	4.00E-02	--	--
Molybdenum	7439-98-7	--	0.0079	1.00E-03	--[c]	--	1.00E+00	--	--
Nickel	7440-02-0	--	0.0050	2.00E-04	--[c]	--	4.00E-02	--	--
Nitrate	14797-55-8	--	110	1.00E-03	--[c]	--	1.00E+00	--	--
Selenium	7782-49-2	--	0.0042	1.00E-03	--[c]	--	1.00E+00	--	--
Strontium	7440-24-6	--	0.93	1.00E-03	--[c]	--	1.00E+00	--	--
Styrene	100-42-5	Yes	0.00014	3.70E-02	8.98E-09	--	1.00E+00	--	--
Sulfate	14808-79-8	--	127	1.00E-03	--[c]	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	3.30E-02	1.02E-08	2.10E-03	1.00E+00	2.14E-11	0.19
Tin	7440-31-5	--	0.00010	1.00E-03	--[c]	--	1.00E+00	--	--
Toluene	108-88-3	Yes	0.000072	3.10E-02	3.84E-09	--	1.00E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	2.27E-07	4.60E-02	1.00E+00	1.04E-09	93
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	2.46E-09	--	1.00E+00	--	--
Vanadium	7440-62-2	--	0.017	1.00E-03	--[c]	--	1.00E+00	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	1.82E-08	--	1.00E+00	--	--
Zinc	7440-66-6	--	0.0060	6.00E-04	--[c]	--	1.00E+00	--	--
Total ELCR								1.12E-08	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics)
[c] Dermal intake of nonvolatiles in sweat lodge vapor is presented in Table D-7
[d]K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).
[c]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles
-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.
EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistance Lifeways*

Attachment Table D-6. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment

Hazard quotient and cancer risk from dermal exposure to nonvolatile compounds in sweat lodge condensed water
Yakama Nation Sweat Lodge Scenario (Ridolfi, 2007)

Model assumes concentration of nonvolatiles in condensed water is equal to concentration in water used to create steam

Model assumes 100% volatilization of volatiles and semi-volatiles; hence, dermal intake from volatiles and semi-volatiles in condensed water can be neglected (Harris and Harper 2004, Appendix 4)

Yakama Nation exposure scenario (Ridolfi, 2007) does not include a model for estimating contaminant concentrations in sweathouse air from contaminant concentrations in groundwater used to make steam. Evaluation performed using steam model from CTUIR sweat lodge scenario (Harris and Harper 2004).

Parameter	Symbol	Value	Unit	Source
Dermal Intake of Analytes - Nonvolatiles Condensed Liquid	I_{di}	Calculated Value	mg/kg-day	Equation 43
Groundwater Concentration	C_{iw}	Analyte- specific	mg/L	ECF-100FR3-11-0024
Skin Surface Area - adult	SA	1.8	m^2	Harris and Harper, 2004
Analyte-specific permeability constant	K_p	Analyte- specific	cm/hr	EPA/540/R/99/005
Length of sweat event - adult	ET	7	hr/event	Ridolfi, 2007
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	70	years	Harris and Harper, 2004
Average body weight - adult	BW	70	kg	Harris and Harper, 2004
Averaging time (noncarcinogens)[a]	AT	70	years	Harris and Harper, 2004
Averaging time (carcinogens)[a]	AT	70	years	Harris and Harper, 2004
Reference Dose - Oral	RfD_o	Analyte-specific	mg/kg-day	EPA, 2012
Gastrointestinal Absorption Factor	GIABS	Analyte-specific	unitless	EPA, 2012
Cancer Slope Factor - Oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	EPA, 2012
Conversion factor	CF1	365	day/year	1 year = 365 days
Conversion factor	CF3	10	L/m^3-cm	1 L = 0.01 m^3 * 10 cm

[a] Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for both carcinogens and noncarcinogens to account for lifetime intake rather than annual intake

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*
Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment* .

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{iw} (mg/L)	K_p[b] (cm/hr)	I_{di}(noncarcinogen) (mg/kg-day)	RfD_o[c] (mg/kg-day)	GIABS[c] (unitless)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	--(c)	6.00E-03	1.00E+00	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	4.20E-02	--(c)	7.00E-02	1.00E+00	--	--
1,4-Dioxane	123-91-1	Yes[a]	0.0076	3.30E-04	--(c)	3.00E-02	1.00E+00	--	--
Acetone[d]	67-64-1	Yes	0.0013	5.12E-04	--(c)	9.00E-01	1.00E+00	--	--
Aluminum	7429-90-5	--	0.022	1.00E-03	4.01E-05	1.00E+00	1.00E+00	4.01E-05	0.0035
Arsenic	7440-38-2	--	0.0080	1.00E-03	1.61E-05	3.00E-04	1.00E+00	5.37E-02	4.7
Barium	7440-39-3	--	0.11	1.00E-03	1.98E-04	2.00E-01	7.00E-02	1.41E-02	1.2
Boron	7440-42-8	--	0.14	1.00E-03	2.45E-04	2.00E-01	1.00E+00	1.22E-03	0.11
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	--(c)	1.40E-03	1.00E+00	--	--
Chloride	16887-00-6	--	37	1.00E-03	6.59E-02	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	--(c)	2.00E-02	1.00E+00	--	--
Chloroform	67-66-3	Yes	0.00046	6.30E-03	--(c)	1.00E-02	1.00E+00	--	--
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	--(c)	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	4.73E-05	1.50E+00	1.30E-02	2.42E-03	0.21
Cobalt	7440-48-4	--	0.00017	4.00E-04	1.25E-07	3.00E-04	1.00E+00	4.15E-04	0.037
Copper	7440-50-8	--	0.0023	1.00E-03	4.22E-06	4.00E-02	1.00E+00	1.08E-04	0.0093
Fluoride	16984-48-8	--	0.52	1.00E-03	9.35E-04	6.00E-02	1.00E+00	1.56E-02	1.4
Hexavalent Chromium	18540-29-9	--	0.020	2.00E-03	7.22E-05	3.00E-03	2.50E-02	9.62E-01	85
Iron	7439-89-6	--	0.083	1.00E-03	1.49E-04	7.00E-01	1.00E+00	2.12E-04	0.019
Lead	7439-92-1	--	0.00020	1.00E-04	3.60E-08	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	6.30E-05	2.00E-03	1.00E+00	3.15E-02	2.8
Manganese	7439-96-5	--	0.0080	1.00E-03	1.08E-05	2.80E-02	4.00E-02	1.13E-02	0.98
Molybdenum	7439-98-7	--	0.0079	1.00E-03	1.43E-05	5.00E-03	1.00E+00	2.85E-03	0.25
Nickel	7440-02-0	--	0.0050	2.00E-04	1.30E-06	2.00E-02	4.00E-02	2.25E-03	0.20
Nitrate	14797-55-8	--	110	1.00E-03	1.97E-01	7.10E+00	1.00E+00	2.78E-02	2.4
Selenium	7782-49-2	--	0.0042	1.00E-03	7.57E-06	5.00E-03	1.00E+00	1.51E-06	0.13
Strontium	7440-24-6	--	0.93	1.00E-03	1.67E-03	6.00E-01	1.00E+00	2.79E-03	0.25
Styrene	100-42-5	Yes	0.00014	3.70E-02	--(c)	2.00E-01	1.00E+00	--	--
Sulfate	14808-79-8	--	127	1.00E-03	2.28E-01	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	3.30E-02	--(c)	6.00E-03	1.00E+00	--	--
Tin	7440-31-5	--	0.00010	1.00E-03	1.80E-07	6.00E-01	1.00E+00	3.00E-07	0.000026
Toluene	108-88-3	Yes	0.000072	3.10E-02	--(c)	8.00E-02	1.00E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	--(c)	5.00E-04	1.00E+00	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	--(c)	3.00E-01	1.00E+00	--	--
Vanadium	7440-62-2	--	0.017	1.00E-03	3.06E-05	5.00E-03	1.00E+00	6.12E-03	0.54
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	--(c)	2.00E-01	1.00E+00	--	--
Zinc	7440-66-6	--	0.0060	6.00E-04	6.48E-06	3.00E-01	1.00E+00	2.16E-05	0.0019
Total HI								1.14E+00	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics)

[c] Model assumes 100% volatilization of volatiles and semi-volatiles; hence, dermal intake from volatiles and semi-volatiles in condensed water can be neglected (Harris and Harper 2004, Appendix 4)

[d]K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).

[e]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.

HI= hazard index.

HQ = hazard quotient.

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{iw} (mg/L)	K_p[b] (cm/hr)	I_{di}(carcinogen) (mg/kg-day)	CSF_o[c] $(mg/kg\text{-}day)^{-1}$	GIABS[c] (unitless)	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	--(c)	9.10E-02	1.00E+00	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	4.20E-02	--(c)	5.40E-03	1.00E+00	--	--
1,4-Dioxane	123-91-1	Yes[a]	0.0076	3.30E-04	--(c)	1.00E-01	1.00E+00	--	--
Acetone[d]	67-64-1	Yes	0.0013	5.12E-04	--(c)	--	1.00E+00	--	--
Aluminum	7429-90-5	--	0.022	1.00E-05	4.01E-05	--	1.00E+00	--	--
Arsenic	7440-38-2	--	0.0080	1.00E-03	1.61E-05	1.50E+00	1.00E+00	2.42E-05	100
Barium	7440-39-3	--	0.11	1.00E-03	1.98E-04	--	7.00E-02	--	--
Boron	7440-42-8	--	0.14	1.00E-03	2.45E-04	--	1.00E+00	--	--
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	--(c)	--	1.00E+00	--	--
Chloride	16887-00-6	--	37	1.00E-03	6.59E-02	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	--(c)	--	1.00E+00	--	--
Chloroform	67-66-3	Yes	0.00046	6.30E-03	--(c)	3.10E-02	1.00E+00	--	--
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	--(c)	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	4.73E-05	--	1.30E-02	--	--
Cobalt	7440-48-4	--	0.00017	4.00E-04	1.25E-07	--	1.00E+00	--	--
Copper	7440-50-8	--	0.0023	1.00E-03	4.22E-06	--	1.00E+00	--	--
Fluoride	16984-48-8	--	0.52	1.00E-03	9.35E-04	--	1.00E+00	--	--
Hexavalent Chromium	18540-29-9	--	0.020	2.00E-03	7.22E-05	--	2.50E-02	--	--
Iron	7439-89-6	--	0.083	1.00E-03	1.49E-04	--	1.00E+00	--	--
Lead	7439-92-1	--	0.00020	1.00E-04	3.60E-06	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	6.30E-05	--	1.00E+00	--	--
Manganese	7439-96-5	--	0.0080	1.00E-03	1.08E-05	--	4.00E-02	--	--
Molybdenum	7439-98-7	--	0.0079	1.00E-03	1.43E-05	--	1.00E+00	--	--
Nickel	7440-02-0	--	0.0050	2.00E-04	1.30E-06	--	4.00E-02	--	--
Nitrate	14797-55-8	--	110	1.00E-03	1.97E-01	--	1.00E+00	--	--
Selenium	7782-49-2	--	0.0042	1.00E-03	7.57E-06	--	1.00E+00	--	--
Strontium	7440-24-6	--	0.93	1.00E-03	1.67E-03	--	1.00E+00	--	--
Styrene	100-42-5	Yes	0.00014	3.70E-02	--(c)	--	1.00E+00	--	--
Sulfate	14808-79-8	--	127	1.00E-03	2.28E-01	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	3.30E-02	--(c)	2.10E-03	1.00E+00	--	--
Tin	7440-31-5	--	0.00010	1.00E-03	1.80E-07	--	1.00E+00	--	--
Toluene	108-88-3	Yes	0.000072	3.10E-02	--(c)	--	1.00E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	--(c)	4.60E-02	1.00E+00	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	--(c)	--	1.00E+00	--	--
Vanadium	7440-62-2	--	0.017	1.00E-03	3.06E-05	--	1.00E+00	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	--(c)	--	1.00E+00	--	--
Zinc	7440-66-6	--	0.0060	6.00E-04	6.48E-06	--	1.00E+00	--	--
Total ELCR								2.42E-05	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics)

[c] Model assumes 100% volatilization of volatiles and semi-volatiles; hence, dermal intake from volatiles and semi-volatiles in condensed water can be neglected (Harris and Harper 2004, Appendix 4)

[d]K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).

[e]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*

Attachment Table D-7. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment
Hazard quotient and cancer risk from dermal exposure to nonvolatile compounds in sweat lodge vapor
Yakama Nation Sweat Lodge Scenario (Ridolfi, 2007)

Yakama Nation exposure scenario (Ridolfi, 2007) does not include a model for estimating contaminant concentrations in sweat lodge air from contaminant concentrations in groundwater used to make steam. Evaluation performed using steam model from CTUIR sweat lodge scenario (Harris and Harper 2004).

Parameter	Symbol	Value	Unit	Source
Dermal Intake of Analytes - Nonvolatiles Vapor	$I_{v,d}$	Calculated Value	mg/kg-day	Equation 44
Groundwater Concentration	C_{dw}	Analyte- specific	mg/L	ECF-100FR3-11-0024
Skin Surface Area - adult	SA	1.8	m^2	Harris and Harper, 2004
Analyte-specific permeability constant	K_p	Analyte- specific	cm/hr	EPA/540/R/99/005
Length of sweat event-adult	ET	7	hr/event	Ridolfi, 2007
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	70	years	Harris and Harper, 2004
Average body weight - adult	BW	70	kg	Harris and Harper, 2004
Averaging time (noncarcinogens)[a]	AT	70	years	Harris and Harper, 2004
Averaging time (carcinogens)[a]	AT	70	years	Harris and Harper, 2004
Molecular weight of water	MW_{H_2O}	18	g/mole	Harris and Harper, 2004
Ideal gas law constant	R	62.37	(mmHg-L)/gmole-K)	Harris and Harper, 2004
Temperature inside of the sweat lodge[b]	T	338.7	K	Harris and Harper, 2004
Density of liquid water	ρ_w	1000	g/L	Harris and Harper, 2004
Reference Dose - Oral	RfD_o	Analyte-specific	mg/kg-day	EPA, 2012
Gastrointestinal Absorption Factor	GIABS	Analyte-specific	unitless	EPA, 2012
Cancer Slope Factor - Oral	CSF_o	Analyte-specific	$(mg/kg\text{-}day)^{-1}$	EPA, 2012
Conversion factor	CF1	365	day/year	1 year = 365 days
Conversion factor	CF3	10	$L/m^3\text{-}cm$	$1 L = 0.01 m^3 * 10 cm$

[a] Averaging time of 1 year provided in Harris and Harper, 2004 was replaced with 70 years for both carcinogens and noncarcinogens to account for lifetime intake rather than annual intake

[b] Temperature of 389 K provided in Harris and Harper, 2004 was replaced with 338.7 K (150°F) for consistency with stated assumption in Harris and Harper, 2004 that sweat lodge internal temperature is maintained at 150 °F.

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*

EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*
Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment* .

Non-cancer HQ calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	K_p[b] (cm/hr)	$I_{v,d}$(noncarcinogen) (mg/kg-day)	RfD_o[c] (mg/kg-day)	GIABS[d] (unitless)	HQ (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	--(c)	6.00E-03	1.00E+00	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	4.20E-02	--(c)	7.00E-02	1.00E+00	--	--
1,4-Dioxane	123-91-1	Yes[e]	0.0076	3.30E-04	--(c)	3.00E-02	1.00E+00	--	--
Acetone[e]	67-64-1	Yes	0.0013	5.12E-04	--(c)	9.00E-01	1.00E+00	--	--
Aluminum	7429-90-5	--	0.022	1.00E-03	6.58E-08	1.00E+00	1.00E+00	6.56E-08	0.0035
Arsenic	7440-38-2	--	0.0090	1.00E-03	2.64E-08	3.00E-04	1.00E+00	8.80E-05	4.7
Barium	7440-39-3	--	0.11	1.00E-03	3.24E-08	2.00E-01	7.00E-02	2.92E-06	1.2
Boron	7440-42-8	--	0.14	1.00E-03	4.01E-08	2.00E-01	1.00E+00	2.01E-07	0.11
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	--(c)	1.40E-03	1.00E+00	--	--
Chloride	16887-00-6	--	37	1.00E-03	1.08E-05	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	--(c)	2.00E-02	1.00E+00	--	--
Chloroform	67-66-3	Yes	0.00046	6.80E-03	--(c)	1.00E-02	1.00E+00	--	--
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	--(c)	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	7.74E-09	1.50E+00	1.30E-02	3.97E-07	0.21
Cobalt	7440-48-4	--	0.00017	4.00E-04	2.04E-11	3.00E-04	1.00E+00	6.80E-08	0.037
Copper	7440-50-8	--	0.0023	1.00E-03	6.92E-10	4.00E-02	1.00E+00	1.73E-08	0.0093
Fluoride	16984-48-8	--	0.52	1.00E-03	1.53E-07	6.00E-02	1.00E+00	2.55E-06	1.4
Hexavalent Chromium	18540-29-9	--	0.020	1.00E-03	1.18E-08	3.00E-03	2.50E-02	1.58E-04	85
Iron	7439-89-6	--	0.083	2.00E-03	2.43E-08	7.00E-01	1.00E+00	3.48E-08	0.019
Lead	7439-92-1	--	0.00020	1.00E-04	5.80E-12	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	1.03E-08	2.00E-03	1.00E+00	5.16E-06	2.8
Manganese	7439-96-5	--	0.0080	1.00E-03	1.77E-09	2.40E-02	4.00E-02	1.84E-05	0.99
Molybdenum	7439-98-7	--	0.0079	1.00E-03	2.34E-09	5.00E-03	1.00E+00	4.68E-07	0.25
Nickel	7440-02-0	--	0.0050	1.00E-04	2.95E-10	2.00E-02	4.00E-02	3.69E-07	0.20
Nitrate	14797-55-8	--	110	1.00E-03	3.23E-05	7.10E+00	1.00E+00	4.55E-06	2.4
Selenium	7782-49-2	--	0.0042	1.00E-03	1.24E-09	5.00E-03	1.00E+00	2.48E-07	0.13
Strontium	7440-24-6	--	0.93	1.00E-03	2.74E-07	6.00E-01	1.00E+00	4.57E-07	0.25
Styrene	100-42-5	Yes	0.00014	3.70E-02	--(c)	2.00E-01	1.00E+00	--	--
Sulfate	14808-79-8	--	127	1.00E-03	3.75E-05	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	3.30E-02	--(c)	6.00E-03	1.00E+00	--	--
Tin	7440-31-5	--	0.00010	1.00E-03	2.95E-11	6.00E-01	1.00E+00	4.92E-11	0.000026
Toluene	108-88-3	Yes	0.000072	3.10E-02	--(c)	8.00E-02	1.00E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	--(c)	5.00E-04	1.00E+00	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	--(c)	3.00E-01	1.00E+00	--	--
Vanadium	7440-62-2	--	0.017	1.00E-03	5.01E-08	5.00E-03	1.00E+00	1.00E-05	0.54
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	--(c)	2.00E-01	1.00E+00	--	--
Zinc	7440-66-6	--	0.0060	6.00E-04	1.06E-09	3.00E-01	1.00E+00	3.54E-09	0.0019
Total HI								1.86E-04	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics)

[c] Dermal intake of volatiles and semi-volatiles is presented in Table D-5

[d]K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).

[e]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = indicates toxicity criteria not available to quantify contaminant's noncancer hazard via this exposure route.

HI= hazard index.

HQ = hazard quotient.

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (mg/L)	K_p[b] (cm/hr)	$I_{v,d}$(carcinogen) (mg/kg-day)	CSF_o[c] $(mg/kg\text{-}day)^{-1}$	GIABS[d] (unitless)	Risk (unitless)	% Contribution
1,2-Dichloroethane	107-06-2	Yes	0.00010	4.20E-03	--(c)	9.10E-02	1.00E+00	--	--
1,4-Dichlorobenzene	106-46-7	Yes	0.00024	4.20E-02	--(c)	5.40E-03	1.00E+00	--	--
1,4-Dioxane	123-91-1	Yes[e]	0.0076	3.30E-04	--(c)	1.00E-01	1.00E+00	--	--
Acetone[e]	67-64-1	Yes	0.0013	5.12E-04	--(c)	--	1.00E+00	--	--
Aluminum	7429-90-5	--	0.022	1.00E-03	6.58E-08	--	1.00E+00	--	--
Arsenic	7440-38-2	--	0.0090	1.00E-03	2.64E-08	1.50E+00	1.00E+00	3.96E-09	100
Barium	7440-39-3	--	0.11	1.00E-03	3.24E-08	--	7.00E-02	--	--
Boron	7440-42-8	--	0.14	1.00E-03	4.01E-08	--	1.00E+00	--	--
Bromomethane	74-83-9	Yes	0.00051	2.80E-03	--(c)	--	1.00E+00	--	--
Chloride	16887-00-6	--	37	1.00E-03	1.08E-05	--	--	--	--
Chlorobenzene	108-90-7	Yes	0.00015	2.80E-02	--(c)	--	1.00E+00	--	--
Chloroform	67-66-3	Yes	0.00046	6.80E-03	--(c)	3.10E-02	1.00E+00	--	--
Chloromethane	74-87-3	Yes	0.000077	3.30E-03	--(c)	--	1.00E+00	--	--
Chromium	7440-47-3	--	0.026	1.00E-03	7.74E-09	--	1.30E-02	--	--
Cobalt	7440-48-4	--	0.00017	4.00E-04	2.04E-11	--	1.00E+00	--	--
Copper	7440-50-8	--	0.0023	1.00E-03	6.92E-10	--	1.00E+00	--	--
Fluoride	16984-48-8	--	0.52	1.00E-03	1.53E-07	--	1.00E+00	--	--
Hexavalent Chromium	18540-29-9	--	0.020	2.00E-03	1.18E-08	--	2.50E-02	--	--
Iron	7439-89-6	--	0.083	1.00E-03	2.43E-08	--	1.00E+00	--	--
Lead	7439-92-1	--	0.00020	2.00E-04	5.80E-12	--	1.00E+00	--	--
Lithium	7439-93-2	--	0.035	1.00E-03	1.03E-08	--	1.00E+00	--	--
Manganese	7439-96-5	--	0.0080	1.00E-03	1.77E-09	--	4.00E-02	--	--
Molybdenum	7439-98-7	--	0.0079	1.00E-03	2.34E-09	--	1.00E+00	--	--
Nickel	7440-02-0	--	0.0050	2.00E-04	2.95E-10	--	4.00E-02	--	--
Nitrate	14797-55-8	--	110	1.00E-03	3.23E-05	--	1.00E+00	--	--
Selenium	7782-49-2	--	0.0042	1.00E-03	1.24E-09	--	1.00E+00	--	--
Strontium	7440-24-6	--	0.93	1.00E-03	2.74E-07	--	1.00E+00	--	--
Styrene	100-42-5	Yes	0.00014	3.70E-02	--(c)	--	1.00E+00	--	--
Sulfate	14808-79-8	--	127	1.00E-03	3.75E-05	--	--	--	--
Tetrachloroethene	127-18-4	Yes	0.00018	3.30E-02	--(c)	2.10E-03	1.00E+00	--	--
Tin	7440-31-5	--	0.00010	1.00E-03	2.95E-11	--	1.00E+00	--	--
Toluene	108-88-3	Yes	0.000072	3.10E-02	--(c)	--	1.00E+00	--	--
Trichloroethene	79-01-6	Yes	0.011	1.20E-02	--(c)	4.60E-02	1.00E+00	--	--
Trichloromonofluoromethane	75-69-4	Yes	0.00011	1.30E-02	--(c)	--	1.00E+00	--	--
Vanadium	7440-62-2	--	0.017	1.00E-03	5.01E-08	--	1.00E+00	--	--
Xylenes (total)	1330-20-7	Yes	0.00020	5.30E-02	--(c)	--	1.00E+00	--	--
Zinc	7440-66-6	--	0.0060	6.00E-04	1.06E-09	--	1.00E+00	--	--
Total ELCR								3.96E-09	100

[a]EPA, 2012, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

[b] EPA/540/R/99/005 Exhibit 3-1 (inorganics) and Exhibit B-3 (organics)

[c] Dermal intake of volatiles and semi-volatiles is presented in Table D-5

[d]K_p value was taken from ORNL, 2010, The Risk Assessment Information System (RAIS).

[e]Defined as a semivolatile per EPA SW-846 Method 8270 for semivolatiles

-- = indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

ELCR = excess lifetime cancer risk.

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final.*
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*

Attachment Table D-8. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment
Cancer risk from inhalation of volatile radioactive contaminants in sweat lodge vapor
Yakama Nation Sweat Lodge Scenario (Ridolfi, 2007)

Yakama Nation exposure scenario (Ridolfi, 2007) does not include a model for estimating contaminant concentrations in sweat lodge air from contaminant concentrations in groundwater used to make steam. Evaluation performed using steam model from CTUIR sweat lodge scenario (Harris and Harper 2004).

Parameter	Symbol	Value	Unit	Source
Inhalation Intake of Analytes - Volatile Radionuclides	I_{inh}	Calculated Value	pCi	Equation 33
Groundwater Concentration	C_{dw}	Analyte- specific	pCi/L	ECF-100FR3-11-0024
Cumulative Volume of water used in a sweat	$V_{w,total}$	4	L	Harris and Harper, 2004
Radius of Sweat Lodge	r	1	m	Harris and Harper, 2004
Inhalation rate- adult	IR	26	m^3/day	Ridolfi, 2007
Length of sweat event- adult[a]	ET	0.292	7/24 days/event	Ridolfi, 2007
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	70	years	Harris and Harper, 2004
The constant pi	π	3.14159	unitless	--
Slope Factor - Inhalation	SF_i	Analyte- specific	risk/pCi	EPA, 2001

[a] For Sweat lodge inhalation exposure, exposure time of 7 hr was replaced with 7/24 days/event so that the intake values have appropriate units (mg/kg-day or pCi) when calculated using the inhalation equations provided in Harris and Harper, 2004

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*
Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment .*

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (pCi/L)	I_{inh} (radiological) (pCi)	Sf_i[b] (risk/pCi)	Risk (unitless)	% Contribution
Americium-241	14596-10-2	--	0.13	--(c)	2.81E-08	--	--
Carbon-14	14762-75-5	--	12	--(c)	7.07E-12	--	--
Gross alpha	12587-46-1	--	6.2	--(c)	--	--	--
Plutonium-238	13981-16-3	--	0.24	--(c)	3.36E-08	--	--
Plutonium-239/240	15117-48-3	--	0.70	--(c)	3.33E-08	--	--
Strontium-90	10098-97-2	--	3.3	--(c)	1.05E-10	--	--
Technetium-99	14133-76-7	--	6.1	--(c)	1.41E-11	--	--
Tritium	10028-17-8	Yes	2,700	5.00E+08	5.62E-14	2.81E-05	100
Total ELCR						2.81E-05	100

[a] Volatile radioactive contaminants as defined by EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

[b] EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

[c] Inhalation intake of nonvolatile radionuclides is presented in Table D-9
-- = indicates radionuclide toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.
ELCR = excess lifetime cancer risk.
EPA/540/R-92/003 *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Preliminary Remediation Goals)* .
Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*

Attachment Table D-9. 100-FR-3 Groundwater Operable Unit Native American Risk Assessment
Cancer risk from inhalation of nonvolatile radioactive contaminants in sweat lodge vapor
Yakama Nation Sweat Lodge Scenario (Ridolfi, 2007)

Yakama Nation exposure scenario (Ridolfi, 2007) does not include a model for estimating contaminant concentrations in sweat lodge air from contaminant concentrations in groundwater used to make steam. Evaluation performed using steam model from CTUIR sweat lodge scenario (Harris and Harper 2004).

Parameter	Symbol	Value	Unit	Source
Inhalation Intake of Analytes - Nonvolatile Radionuclides	I_{inh}	Calculated Value	pCi	Equation 38
Groundwater Concentration	C_{dw}	Analyte- specific	pCi/L	ECF-100FR3-11-0024
Cumulative Volume of water used in a sweat	$V_{w,total}$	4	L	Harris and Harper, 2004
Inhalation rate- adult	IR	26	m^3/day	Ridolfi, 2007
Length of sweat event- adult[a]	ET	0.292	7/24 days/event	Ridolfi, 2007
Exposure Frequency or Number of sweats per year	EF	365	events/year	Harris and Harper, 2004
Exposure duration or number of years a person sweats in a lifetime - adult	ED	70	years	Harris and Harper, 2004
Molecular weight of water	MW_w	18	g/mole	Harris and Harper, 2004
Density of liquid water	ρ_w	1000	g/L	Harris and Harper, 2004
Temperature of the sweat lodge[b]	T	338.7	K	Harris and Harper, 2004
Ideal gas law constant	R	0.06237	(mmHg-m^3)/(gmole-K)	Harris and Harper, 2004
Slope Factor - Inhalation	SF_i	Analyte-specific	risk/pCi	EPA, 2001

[a] For Sweat lodge inhalation exposure, exposure time of 7 hr was replaced with 7/24 days/event so that the intake values have appropriate units (mg/kg-day of pCi) when calculated using the inhalation equations provided in Harris and Harper, 2004.

[b] Temperature of 389 K provided in Harris and Harper, 2004 was replaced with 338.7 K (150°F) for consistency with stated assumption in Harris and Harper, 2004 that sweat lodge internal temperature is maintained at 150°F.

ECF-100FR3-11-0024, *Calculation of Exposure Point Concentrations for the 100-FR-3 Groundwater Operable Unit*

EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways.*

Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment*.

Cancer risk calculation

Nonradioactive Analyte Name	CAS #	Volatile[a]	C_{dw} (pCi/L)	I_{inh} (radiological) (pCi)	Sf_i[b] (risk/pCi)	Risk (unitless)	% Contribution
Americium-241	14596-10-2	--	0.13	4.13E+03	2.81E-08	1.16E-04	10
Carbon-14	14762-75-5	--	12	3.76E+05	7.07E-12	2.66E-06	0.24
Gross alpha	12587-46-1	--	6.2	1.95E+05	--	--	--
Plutonium-238	13981-16-3	--	0.24	7.46E+03	3.36E-08	2.51E-04	22
Plutonium-239/240	15117-48-3	--	0.70	2.21E+04	3.33E-08	7.37E-04	66
Strontium-90	10098-97-2	--	3.3	1.05E+05	1.05E-10	1.10E-05	0.98
Technetium-99	14133-76-7	--	6.1	1.94E+05	1.41E-11	2.73E-06	0.24
Tritium	10028-17-8	Yes	2,700	--(c)	5.62E-14	--	--
Total ELCR						1.12E-03	100

[a] Volatile radioactive contaminants as defined by EPA, 2001, *Health Effects Assessment Summary Tables* database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

[b] EPA, 2001, Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

[c] Inhalation intake of volatile radionuclides in presented in table D-8

-- = indicates radionuclide toxicity criteria not available to quantify contaminant's cancer risk via this exposure route

ELCR = excess lifetime cancer risk.

EPA/540/R-92/003 *Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part B, Development of Preliminary Remediation Goals,*.

Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*