Appendix F

Human Health Risk Assessment

This appendix presents the detailed calculations used to estimate risks to human health. It includes the exposure factors, equations, abbreviations, assumptions, and references. Separate spreadsheets for ground water ingestion for the near-term and 20-year assumptions have also been provided. The following spreadsheets are included in this appendix:

- Overview (Exposure Factors, Equations, Abbreviations, and COPCs) F–3
- Contaminant Concentrations—Near-Term Ground Water Concentrations F–6
- Toxicity Factors F–8
- Lower Montezuma Creek Exposure Scenario—Reasonable Maximum Exposure F–10
- Lower Montezuma Creek Recreational Exposure Scenario—Central Tendency F–13
- Middle Canyon Recreational Exposure Scenario—Reasonable Maximum Exposure . F–16
- Middle Canyon Recreational Exposure Scenario—Central Tendency F–19
- Upper Canyon Recreational Exposure Scenario—Reasonable Maximum Exposure... F–22
- Upper Canyon Recreational Exposure Scenario—Central Tendency F–25
- OU III Ground Water Consumption From the Alluvial Aquifer—Reasonable Maximum Exposure Assumptions, Near-Term Exposure F–28
- OU III Ground Water Consumption From the Upper Flow System—Central Tendency Assumptions, Near-Term Exposure F–31
- Contaminant Concentrations with Modeled Uranium Concentrations in Ground Water F–37
- OU III Ground Water Consumption from the Alluvial Aquifer—Reasonable Maximum Exposure Assumptions, Long-Term Exposure F–39
- OU III Ground Water Consumption from the Upper Flow System—Central Tendency Assumptions, Long-Term Exposure F–42

End of current text

Exposure Factors, Equations, Abbreviations, and COPCs

Exposure Factors (See Exposure Scenario Worksheets for Values)

Factor	Abbreviation	Units
Exposure Frequency	EF	days/year
Daily Exposure Period	DEP	hours/day
Exposure Duration	ED	years
Averaging Time-Cancer	AT-c	days
Averaging Time-Non Cancer	AT-NC	days
Soil-Sediment Ingestion Rate	IR	mg/day
Fraction Intake From Source	FI	fraction
Inhalation Rate	Ihl	m^3/day
Surface Water Ingestion Rate	Swl	l/day
Ground Water Ingestion Rate	Gwl	l/day
Body Weight	BW	kg
Hours per Day	HpD	hr/day
Conversion Factor-Solids	Con-s	mg/kg
Conversion Factor-Water	Con-w	µg/mg
Conversion Factor- Solids rad	Con-sr	mg/gr
Conversion Factor-Dermal	CF	l/cm^3
µR/mrem	Con-e:d	µR/mrem
gamma exposure fraction	gef	fyear exposed
gamma shield and roughness factor	Se	ftransmitted

Equations

See Specific Exposure Scenario Worksheets

Abbreviations

Abbreviation	Description
EF	Exposure Frequency (days/year)
DEP	Daily Exposure Period
ED	Exposure Duration (years)
AT-c	Averaging Time-Cancer (days)
AT-NC	Averaging Time-Non Cancer (days)
IR-S	Soil-Sediment Ingestion Rate
FI	Fraction Intake From Source
IR-A	*Inhalation Rate*
IR-SW	Surface Water Ingestion Rate (l/day)
IR-GW	Ground Water Ingestion Rate (l/day)
IR -Play	Water ingestion rate during play at the edge of the river (l/day)
BW	Body Weight (kg)
HpD	Hours per Day
CF	Conversion factor (media dependant)
CDI	Chronic Daily Intake (mg/kg-day)
mg	milligrams
l	liters
Cw	Chemical concentration in water (mg/l or pCi/l)
Cs	Chemical concentration in soil (mg/kg or pCi/kg)
SA	Skin surface area available for contact (cm2)
cm	centimeters
PC	Chemical specific dermal permeability constant (cm/hr)
HQ	Hazard Quotient (unitless)
HI	Hazard Index (unitless)
SF	*Slope Factor (kg-day/mg or risk/pCi)*
ET	Exposure Time (dermal) (hr/day)
RME	Reasonable Maximum Exposure
CT	Central Tendency
Cf	Chemical concentration in food (mg/kg)
IR-F	Ingestion rate for food (g/day)
RBC	Risk based concentration tables prepared by EPA Region 3
TI	Total Intake (pCi)

COPCs

Chemicals	Soils/ Sediments	Surface Water	Ground Water	Air	Notes
Arsenic	x	x	x	x	See Original risk assessment
Manganese			x		See Original risk assessment
Molybdenum			x		Added for GW; Screened out of non residential scenarios, RBC is 180 µg/l
Nitrate			x		Added for GW; Screened out of non residential scenarios, RBC is 3,700 µg/l
Selenium			x		See Original risk assessment
Sodium		a	a		See Original risk assessment
Sulfate		a	a		See Original risk assessment
Uranium	x	x	x	x	See Original risk assessment
Vanadium			x		See Original risk assessment
Radionuclides					
Uranium-234			x		See Original risk assessment
Uranium-235+D			x		See Original risk assessment
Uranium-238+D			x		See Original risk assessment
Gross alpha	a	a		a	
Gross beta	a			a	
External gamma	x			x	See Original risk assessment

Notes:
1) Pb-210, Ra-226, and Th-230 were eliminated as COPCs because of their decreased concentrations since the original risk assessment.
2) RBC is risk based concentration table from Hubbard, J. Risk-Based Concentration Tables. Memorandum to RBC Table Users. U.S. Environmental Protection Agency, Region III. October 9, 2002. http://www.epa.gov/reg3hwmd/risk/index/htm.
3) Key: x is included and quantified; a is included and not quantifiable.

Contaminant Concentrations Near-Term Ground Water Concentrations

Concentrations are presented by media as follows: 1) soil/sediment, 2) surface water, and 3) ground water
Because of its insignificant contribution to the total risks, the beef ingestion scenario was not evaluated as part of the risk assessment update.

Concentrations in Soils and Sediments (mg/kg or pCi/gr))

	mg/kg					
Compound	**Lower Canyon**	**Middle Canyon**	**Upper Canyon**	**Average**	**Reference**	**Notes**
Arsenic	6.96	7.7	7.8	7.5	5.3	Same data as original risk assessment
Uranium	18.9	28.2	26.3	24.5	3.6	Same data as original risk assessment

	pCi/gr (gamma - µR/hr)					
	Lower Canyon	**Middle Canyon**	**Upper Canyon**	**Average**	**Reference**	**Notes**
U-234	6.1	9.2	8.0	7.8	1.0	Same data as original risk assessment
U-235	0.3	0.4	0.4	0.4	0.1	Same data as original risk assessment
U-238	6.1	9.1	8.2	7.8	1.2	Same data as original risk assessment
External gamma	28.1	29.4	34.2	30.6	15.0	Same data as original risk assessment

Contaminant Concentrations in Surface Water (µg/l or pCi/l)

	µg/l					
Compound	**Lower Canyon**	**Middle Canyon**	**Upper Canyon**	**Average**	**Reference**	**Notes**
Arsenic	1.1	1.4	1.5	1.3	1.5	Canyon data from October 2002 results; original reference area data
Uranium	89.9	147.0	188.0	141.6	2.4	Canyon data from October 2002 results; original reference area data

	pCi/l					
	Lower Canyon	**Middle Canyon**	**Upper Canyon**	**Average**	**Reference**	**Notes**
Uranium-234	27.6	45.6	58.7	44.0	2.3	Estimated from total U based on the isotopic ratios
Uranium-235+D	0.7	1.1	1.4	1.1	0.2	Estimated from total U based on the isotopic ratios
Uranium-238+D	32.3	52.4	69.1	51.3	1.1	Estimated from total U based on the isotopic ratios

Contaminant Concentrations Near-Term Ground Water Concentrations (continued)

Contaminant Concentrations in Ground Water (µg/l or pCi/l)

Compound	Ground Water Concentration (µg/l)	Background Concentration µg/l	Notes
Arsenic	16.5	1.42	Alluvial well 92-11; October 2002 result; original reference area data
Manganese (nonfood)	1.3	30.4	Alluvial well 92-11; October 2002 result; original reference area data
Molybdenum	25	4.4	Alluvial well 92-11; October 2002 result; original reference area data
Nitrate	8668	4444	Alluvial well 92-11; October 2002 result; original reference area data, converted to NO_3 by multiplying by 4.4 assuming the NO_2 +NO_3 is all NO_3
Selenium	85	2.06	Alluvial well 92-11; October 2002 result; original reference area data
Uranium	317	4.78	Alluvial well 92-11; October 2002 result; original reference area data
Vanadium	562	2.83	Alluvial well 92-11; October 2002 result; original reference area data

	Ground Water Concentration (pCi/l)	pCi/l	Notes
U-234	91.6	3.09	Estimated from total U (October 2002 data) based on the isotopic ratios
U-235	4.9	0.191	Estimated from total U (October 2002 data) based on the isotopic ratios
U-238	105.9	1.7	Estimated from total U (October 2002 data) based on the isotopic ratios

Notes: The beef ingestion pathway was not included in the updated risk evaluation because it was found to be insignificant compared to other pathways in the original risk assessment and tissue sampling indicated that the contaminants are not being bioaccumulated.
The air pathway exposure point concentrations are based on contaminant concentrations in soil (see the canyon scenarios).
Estimated isotopic uranium is based on U-234/U-238 ratio of 0.865

Toxicity Factors

Chemical Name	Oral SF kg-day/mg	Inhl SF kg-day/mg	Oral RfD mg/kg-day	Inhl RfD mg/kg-day	Critical Effects	Notes
Arsenic	1.5	15	3.0E-04	0	Cancer, hyperpigmentation, keratosis, vascular	IRIS, November 27, 2002; Inhalation is from the October 2002 RBC Table
Manganese (nonfood)	0	0	2.0E-02	1.43E-05		RBC Table October 2002
Molybdenum	0	0	5.0E-03	0	Increased uric acid	IRIS, November 27, 2002
Nitrate	0	0	1.6E+00		Methemoglobinemia in infants	IRIS, November 27, 2002
Selenium	0	0	5.0E-03	0	Selenosis	IRIS, November 27, 2002
Sodium	NA	NA	NA	NA		No toxicity information is available; risks are not quantified
Sulfate	NA	NA	NA	NA		No toxicity information is available; risks are not quantified
Uranium	0	0	3.0E-03	0	Nephrotoxicity	IRIS October 3, 2002; Uranium, Soluble Salts
Vanadium	0	0	7.0E-03	0		RBC Table October 2002, originally from HEAST

Radionuclides

	Water Ingestion risk/pCi	Food Ingestion risk/pCi	Soil Ingestion risk/pCi	Inhalation risk/pCi	External Exposure Risk/y per pCi/g	Source
Uranium-234	7.07E-11	9.55E-11	1.58E-10	1.14E-08	2.52E-10	USEPA 2001b
Uranium-235+D	7.18E-11	9.76E-11	1.63E-10	1.01E-08	5.43E-07	USEPA 2001b
Uranium-238+D	8.71E-11	1.21E-10	2.10E-10	9.35E-09	1.14E-07	USEPA 2001b

External gamma	8.0E-07 CA/mrem	ISCORS Technical Report No. 1, July 2002

	Ingestion (mrem/pCi)	Inhalation (mrem/pCi)	Notes
U-234	0.000283	0.132	Used in updated assessment
U-235 +D	2.68E-04	1.23E-01	Used in updated assessment
U238 +D	0.00028486	0.118035814	Used in updated assessment

For details on dose conversions for inhalation and ingestion for the uranium isotopes see the dose conversion worksheet

Toxicity Factors (continued)

NA - Not available
IRIS - Integrated Risk Information System
RBC Table - Risk-Based Concentration Table, Memo from Jennifer Hubbard, U. S. EPA Region 3, October 9, 2002.
HEAST - Health Effects Summary Tables, U. S. Environmental Protection Agency

External gamma 5.0E-07 CA/mrem Used in original risk assessment;

	Ingestion	Inhalation	Notes
dose to risk conversions	7.70E-08	2.10E-07	From the original risk assessment
	Fatal CA/mrem		

Radon + D		7.67E-12	
Radium-226 Mill tailings	0.013	0.12	Used in the original risk assessment
	mrem/pCi$_{Ra-226}$	mrem/pCi$_{Ra-226}$	

External gamma 8.0E-07 CA/mrem ISCORS Technical Report No. 1, July 2002

Lower Montezuma Creek Exposure Scenario—Reasonable Maximum Exposure

Description: A recreational exposure scenario in which exposure occurs through periodic visits to the area
Pathways include: Incidental ingestion of soils and sediments, incidental ingestion of surface water, inhalation of particulates and direct gamma

Part 1: Exposure Factors and Equations

Lower Canyon Recreational Exposure Factors

Factor	Abbreviation	Units	Parameters Central Tendency	*RME*
Exposure Frequency	EF	days/year	14	21
Daily Exposure Period	DEP	*hours/day*	*0.68*	1.03
Exposure Duration	ED	years	9	30
Averaging Time-Cancer	AT-c	days	25550	25550
Averaging Time-Non Cancer	AT-NC	days	365	365
Soil-Sediment Ingestion Rate	IR	mg/day	59	114
Fraction Intake From Source	FI	fraction	0.5	1
Inhalation Rate	Ihl	m^3/day	20	20
Surface Water Ingestion Rate	Swl	l/day	0.011	0.026
Ground Water Ingestion Rate[1]	Gwl	l/day	1.4	2
Body Weight	BW	kg	70	59
Hours per Day	HpD	hr/day	24	24
Conversion-solids	Con-s	mg/kg	1.00E+06	1.00E+06
Conversion -water	Con-w	ug/mg	1000	1000
Conversion - solids rad	Con-sr	mg/gr	1000	1000
µR/mrem	Con-e:d	uR/mrem	1.00E+03	1.00E+03
gamma exposure fraction	gef	fyear exposed	0.001086758	0.002469178
gamma shield & roughness factor	Se	ftransmitted	0.5	0.8

[1] Ground water consumption is not segment specific - user ensure continuity (See Residential Consumption)

Equations

Non Radionuclides

1) $CDI_{\text{soil ingestion carcinogenic}}$ = mg/kg * 1 kg/1E 6 mg * EF * IR* (DEP/HpD) * ED * FI / BW / AT –c = mg/kg-day
2) $CDI_{\text{soil ingestion non cancer}}$ = mg/kg * 1kg/1E 6 mg * IR* (DEP/HpD) * EF/ AT_{-NC} BW = mg/kg-day
3) $CDI_{\text{sw ingestion carcinogenic}}$ = mg/l * EF * SwIR * ED * FI / BW / AT –c = mg/kg-day
4) $CDI_{\text{sw ingestion non cancer}}$ = mg/l * SwIR* * EF/ AT_{-NC} / BW = mg/kg-day
5) $CDI_{\text{inhalation of dust carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI / BW / AT-c = mg/kg-day
6) $CDI_{\text{inhalation of dust non carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * (DEP/HpD) ** EF/ AT_{-NC} * FI / BW / = mg/kg-day
7) $CDI_{\text{ground water ingestion carcinogenic}}$ = mg/l * Gwl * EF * ED * FI / BW / AT-c = mg/l-day
8) $CDI_{\text{ground water ingestion non carcinogenic}}$ = mg/l * Gwl * EF/ AT_{-NC} * FI / BW = mg/l-day

[(1)] dust resuspension mg/m^3 = mg/kg soil * 0.011mg/ m^3 * 1 kg/1E6 mg

Radionuclides

9) $TI_{\text{soil ingestion}}$ = pCi/gr * 1gr/1000 mg * IR * (DEP/HpD) * EF * ED * FI = pCi
10) $TI_{\text{sw ingestion}}$ = pCi/l * EF * SwIR * ED * FI = pCi
11) $TI_{\text{inhalation of dust}}$ [(2)] = pCi/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI = pCi
12) $TI_{\text{ground water ingestion}}$ = pCi/l * Gwl * EF * FI * ED = pCi
13 $TExp_{\text{external whole body gamma}}$ = uR/hr * EF * DEP * ED * mrem/µR = mrem

[(2)] dust resuspension pCi/m^3 = pCi/g soil * 0.011mg/m^3 * 1 gr/1000 mg

Lower Montezuma Creek Exposure Scenario—Reasonable Maximum Exposure (continued)

Part 2: Concentrations and Intakes Non Radionuclide and Radionuclide COC's RME Computation

Chemical Name	Exposure Point Concentrations				Chronic Daily Intake - "RME"				Daily Intake - "RME"				
	Soils/ Sediments	Surface Water	Ground Water	Air	Soil/Sediment Combined	Surface Water	Ground Water	Air	Soil/Sediment Combined		Surface Water	Ground Water	Air
	mg/kg	µg/l	µg/l	mg/m^3	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day
Arsenic	6.96	1.1	0	7.656E-08	1.423E-08	0 1.18377E-08	0	2.7463E-11	3.32058E-08	0	2.76213E-08	0	6.408E-11
Uranium	18.9	89.9		2.079E-07	3.864E-08	0 9.67463E-07		7.4578E-11	9.0171E-08	0	2.25741E-06	0	1.74E-10
									0	0	0	0	0

Radionuclide Name	Exposure Point Concentrations					Period Intake (Exposure)				
	Soils/Sediments	Surface Water	Ground Water	Air	gamma	Soils/Sediments		Surface Water	Ground Water	Air	gamma
	pCi/gr	pCi/l	pCi/l	pCi/m^3	µR/hr	pCi		pCi	pCi	pCi	mrem
Uranium-234	6.1	27.6		6.7E-05		18.8	0	447.7		3.6E-02	
Uranium-235+D	0.308	0.7		3.4E-06		0.9	0	11.4		1.8E-03	
Uranium-238+D	6.07	32.3		6.7E-05		18.7	0	524.0		3.6E-02	
External gamma	0				*28.1*						*18.23409*

Lower Montezuma Creek Exposure Scenario—Reasonable Maximum Exposure (continued)

Part 3: Risks and HQ's Non Radionuclides, Risks for Radionuclides RME Computation

	Cancer Risk					Non Cancer Hazard Indicies				
	Ingestion		Inhalation		Sum	Ingestion		Inhalation		
	CDI	Cancer	CDI	Cancer	Cancer	Daily Intake		Daily Intake		Sum
Chemical	mg/kg-day	Risk	mg/kg-day	Risk	Risk	mg/kg-day	HI	mg/kg-day	HI	HI
Arsenic	2.6E-08	3.9E-08	2.7E-11	4.1E-10	4.0E-08	6.1E-08	2.0E-04	6.4E-11	0.0E+00	2.0E-04
Uranium	1.0E-06	0.0E+00	7.5E-11	0.0E+00	0.0E+00	2.3E-06	7.8E-04	1.7E-10	0.0E+00	7.8E-04
Summation		3.9E-08		4.1E-10	4.0E-08		9.9E-04		0.0E+00	9.9E-04

	Ingestion		Inhalation		External		External		External	
		Cancer		Cancer	95% UCL	Risk	95% UCL	Risk	95% UCL	Risk
Radionuclide Name	Total pCi	Risk	Total pCi	Risk	pCi/gr **-Soil**	**Soil**	pCi/gr - **Sediment**	**Sediment**	mrem/period	gamma
Uranium-234	4.7E+02	3.3E-08	3.6E-02	4.1E-10	6.1E+00	9.1E-11	0.0E+00	0.0E+00		
Uranium-235+D	1.2E+01	8.8E-10	1.8E-03	1.9E-11	3.1E-01	9.9E-09	0.0E+00	0.0E+00		
Uranium-238+D	5.4E+02	4.7E-08	3.6E-02	3.4E-10	6.1E+00	4.1E-08	0.0E+00	0.0E+00		
External gamma	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
									18.23409	1.5E-05
Summation		8.1E-08		7.7E-10		5.1E-08		0.0E+00		

Dose and Dose to Risk Assessment	Ingestion		Inhalation		External	
	pCi/year	mrem/year	pCi/year	mrem/year	mrem/year	Total
Mill tailings	3.4E+01	9.7E-03	2.5E-03	3.1E-04	0.61	0.62
30 year CA Risk =		*2.2E-08*		*1.9E-09*	*1.5E-05*	*1.5E-05*

Note: Ingestion and inhalation dose evaluations were based on a Monticello mill tailing specific dose conversion factor based on weighted radionuclide content and indexed to Ra-226. Ra-226 has been eliminated as a COPC because of the reduction to nondetectable levels in ground water and the remediation that was complete on the surface soils. Therefore, new dose conversion factors for ingestion and inhalation were used for the remaining COCs.
Dose from external gamma was estimated by the same method as the original risk assessment using measured µR/hr measurements

Lower Montezuma Creek Recreational Exposure Scenario—Central Tendency

Description: A recreational exposure scenario in which exposure occurs through periodic visits to the area
Pathways include: incidental ingestion of soils and sediments, incidental ingestion of surface water, inhalation of particulates and direct gamma

Part 1: Exposure Factors and Equations

Lower Canyon Recreational Exposure Factors

Factor	Abbreviation	Units	Parameters Central Tendency	Parameters RME
Exposure Frequency	EF	days/year	14	21
Daily Exposure Period	DEP	hours/day	0.68	1.03
Exposure Duration	ED	years	9	30
Averaging Time-Cancer	AT-c	days	25550	25550
Averaging Time-Non Cancer	AT-NC	days	365	365
Soil-Sediment Ingestion Rate	IR	mg/day	59	114
Fraction Intake From Source	FI	fraction	0.5	1
Inhalation Rate	Ihl	m^3/day	20	20
Surface Water Ingestion Rate	Swl	l/day	0.0113	0.026
Ground Water Ingestion Rate[1]	Gwl	l/day	1.4	2
Body Weight	BW	kg	70	59
Hours per Day	HpD	hr/day	24	24
Conversion-solids	Con-s	mg/kg	1.00E+06	1.00E+06
Conversion -water	Con-w	µg/mg	1000	1000
Conversion - solids rad	Con-sr	mg/gr	1000	1000
µR/mrem	Con-e:d	µR/mrem	1.00E+03	1.00E+03
gamma exposure fraction	gef	fyear exposed	0.001086758	0.00246918
gamma shield and *roughness factor*	Se	ftransmitted	0.5	0.8

[1] Ground water consumption is not segment specific - user ensure continuity (See Residential Consumption)

Equations

Non Radionuclides

1) $CDI_{\text{soil ingestion carcinogenic}}$ = mg/kg * 1 kg/1E 6 mg * EF * IR* (DEP/HpD) * ED * FI / BW / AT –c = mg/kg-day
1) $CDI_{\text{soil ingestion carcinogenic}}$ = mg/kg * 1 kg/1E 6 mg * EF * IR* (DEP/HpD) * ED * FI / BW / AT –c = mg/kg-day
2) $CDI_{\text{soil ingestion non cancer}}$ = mg/kg * 1kg/1E 6 mg * IR* (DEP/HpD) * EF/ AT_{-NC} BW = mg/kg-day
3) $CDI_{\text{sw ingestion carcinogenic}}$ = mg/l * EF * SwIR * ED * FI / BW / AT –c = mg/kg-day
4) $CDI_{\text{sw ingestion non cancer}}$ = mg/l * SwIR* * EF/ AT_{-NC} / BW = mg/kg-day
5) $CDI_{\text{inhalation of dust carcinogenic}}$ (1) = mg/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI / BW / AT-c = mg/kg-day
6) $CDI_{\text{inhalation of dust non carcinogenic}}$ (1) = mg/m^3 * Ih-R * (DEP/HpD) ** EF/ AT_{-NC} * FI / BW / = mg/kg-day
7) $CDI_{\text{ground water ingestion carcinogenic}}$ = mg/l * Gwl * EF * ED * FI / BW / AT-c = mg/l-day
8) $CDI_{\text{ground water ingestion non carcinogenic}}$ = mg/l * Gwl * EF/ AT_{-NC} * FI / BW = mg/l-day

(1) dust resuspension mg/ m^3 = mg/kg soil * 0.011mg/ m^3 * 1 kg/1E6 mg

Radionuclides

9) $TI_{\text{soil ingestion}}$ = pCi/gr * 1gr/1000 mg * IR * (DEP/HpD) * EF * ED * FI = pCi
10) $TI_{\text{sw ingestion}}$ = pCi/l * EF * SwIR * ED * FI = pCi
11) $TI_{\text{inhalation of dust}}$ (2) = pCi/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI = pCi
12) $TI_{\text{ground water ingestion}}$ = pCi/l * Gwl * EF * FI * ED = pCi
13 $TExp_{\text{external whole body gamma}}$ = µR/hr * EF * DEP * ED * mrem/µR = mrem

(2) dust resuspension pCi/m^3 = pCi/g soil * 0.011mg/m^3 * 1 gr/1000 mg

Lower Montezuma Creek Recreational Exposure Scenario—Central Tendency (continued)

Part 2: Concentrations and Intakes Non Radionuclide and Radionuclide COC's CT Computation

	Exposure Point Concentrations				Chronic Daily Intake—"Central Tendency"				Daily Intake—"Central Tendency"				
Chemical Name	Soil/Sediment	Surface Water	Ground Water	Air	Soil/Sediment Combined	Surface Water	Ground Water	Air	Soil/Sediment Combined	Surface Water	Ground Water	Air
	mg/kg	µg/l	µg/l	mg/m^3	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day
Arsenic	6.96	1.1	0	7.656E-08	2.04918E-10	0	2.19569E-10	0	1.5282E-12	3.1876E-09	0	3.41553E-09	0	2.37721E-11
Uranium	18.9	89.9		2.079E-07	5.56459E-10	0	1.79448E-08		4.1499E-12	8.656E-09	0	2.79142E-07	0	6.45534E-11
										0	0	0	0	0

	Exposure Point Concentrations					Period Intake (Exposure)					
Radionuclide Name	Soil/Sediment	Surface Water	Ground Water	Air	gamma	Soil/Sediment		Surface Water	Ground Water	Air	gamma	
	pCi/gr	pCi/l	pCi/l	pCi/m^3	µR/hr	pCi		pCi	pCi	pCi	mrem	
Uranium-234	6.1	27.60	0	6.7E-05		0.64	0	19.71		2.4E-03		
Uranium-235+D	0.3	0.70	0	3.4E-06		0.03	0	0.50		1.2E-04		
Uranium-238+D	6.1	32.30	0	6.7E-05		0.64	0	23.06		2.4E-03		Background
External gamma	0.0	0.00			28.1						1.20	

Lower Montezuma Creek Recreational Exposure Scenario—Central Tendency (continued)

Part 3: Risks and HQ's Non Radionuclides, Risks for Radionuclides CT Computation

	Cancer Risk[a]					Non Cancer Hazard Indicies[b]				
	Ingestion		Inhalation		Sum	Ingestion		Inhalation		
	CDI	Cancer	CDI	Cancer	Cancer	Daily Intake		Daily Intake		Sum
Chemical	mg/kg-day	Risk	mg/kg-day	Risk	Risk	mg/kg-day	HI	mg/kg-day	HI	HI
Arsenic	4.2E-10	6.4E-10	1.5E-12	2.3E-11	6.6E-10	6.6E-09	2.2E-05	2.4E-11	0.0E+00	2.2E-05
Uranium	1.9E-08	0.0E+00	4.1E-12	0.0E+00	0.0E+00	2.9E-07	9.6E-05	6.5E-11	0.0E+00	9.6E-05
Summation		6.4E-10		2.3E-11	6.6E-10		1.2E-04		0.0E+00	1.2E-04

	Ingestion		Inhalation		External		External		External	
		Cancer		Cancer	95% UCL	Risk	95% UCL	Risk	95% UCL	Risk
Radionuclide Name	Total pCi	Risk	Total pCi	Risk	pCi/gr **-Soil**	**Soil**	pCi/gr - **Sediment**	**Sediment**	mrem/period	gamma
Uranium-234	2.0E+01	1.4E-09	2.4E-03	2.7E-11	6.1E+00	7.5E-12	0.0E+00	0.0E+00		
Uranium-235+D	5.3E-01	3.8E-11	1.2E-04	1.2E-12	3.1E-01	8.2E-10	0.0E+00	0.0E+00		
Uranium-238+D	2.4E+01	2.1E-09	2.4E-03	2.2E-11	6.1E+00	3.4E-09	0.0E+00	0.0E+00		
External gamma	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
									1.203804	9.6304E-07
Summation		3.5E-09		5.1E-11		4.2E-09		0.0E+00		

Dose & Dose to Risk Assessment	Ingestion		Inhalation		External	
	pCi/year	mrem/year	pCi/year	mrem/year	mrem/year	Total
Mill tailings	5.0E+00	1.4E-03	5.4E-04	6.8E-05	0.13	0.14
30 year CA Risk =		*9.7E-10*		*1.3E-10*	*9.6E-07*	*9.6E-07*

[a]Cancer risk is estimated as follows: CDI × slope factor. The slope factor quantifies toxicity, and it is obtained from the EPA literature (primary source is the Integrated Risk Information System or IRIS). The result is a unitless probability of added cancer risk.
[b]The noncancer hazard index (HI) is the sum of individual hazard quotients (HQ): $HI = HQ_1 + HQ_2 + \ldots HQ_n$. HQ = CDI/Reference dose. Reference dose or RfD is obtained from EPA literature such as IRIS. HI is a unitless, numeric value used to quantify the potential for noncarcinogenic negative health impacts.

Note: Ingestion and inhalation dose evaluations were based on a Monticello mill tailing specific dose conversion factor based on weighted radionuclide content and indexed to Ra-226. Ra-226 has been eliminated as a COPC because of the reduction to nondetectable levels in ground water and the remediation that was complete on the surface soils. Therefore, new dose conversion factors for ingestion and inhalation were used for the remaining COCs.
Dose from external gamma was estimated by the same method as the original risk assessment using measured µR/hr measurements.

Middle Canyon Recreational Exposure Scenario—Reasonable Maximum Exposure

Description: A pass-through recreational exposure scenario in which exposure occurs through periodic visits to the area
Pathways include: incidental ingestion of soils and sediments, incidental ingestion of surface water, inhalation of particulates and direct gamma

Part 1: Exposure Factors and Equations

Middle Canyon Recreational Exposure Factors

Factor	Abbreviation	Units	Parameters Central Tendency	*RME*
Exposure Frequency	EF	days/year	14	21
Daily Exposure Period	DEP	hours/day	0.25	0.5
Exposure Duration	ED	years	9	30
Averaging Time-Cancer	AT-c	days	25550	25550
Averaging Time-Non Cancer	AT-NC	days	365	365
Soil-Sediment Ingestion Rate	IR	mg/day	59	114
Fraction Intake From Source	FI	fraction	0.5	1
Inhalation Rate	Ihl	m^3/day	20	20
Surface Water Ingestion Rate	Swl	l/day	0.004	0.013
Ground Water Ingestion Rate[1]	Gwl	l/day	1.4	2
Body Weight	BW	kg	70	59
Hours per Day	HpD	hr/day	24	24
Conversion-solids	Con-s	mg/kg	1.00E+06	1.00E+06
Conversion -water	Con-w	µg/mg	1000	1000
Conversion - solids rad	Con-sr	mg/gr	1000	1000
µR/mrem	Con-e:d	µR/mrem fyear	1.00E+03	1.00E+03
gamma exposure fraction	gef	exposed	0.000399543	0.00119863
gamma shield and roughness factor	Se	ftransmitted	0.5	0.8

[1] Ground water consumption is not segment specific - user ensure continuity (See Residential Consumption)

Equations

Non Radionuclides

1) $CDI_{\text{soil ingestion carcinogenic}}$ = mg/kg * 1 kg/1E 6 mg * EF * IR* (DEP/HpD) * ED * FI / BW / AT –c = mg/kg-day
2) $CDI_{\text{soil ingestion non cancer}}$ = mg/kg * 1kg/1E 6 mg * IR* (DEP/HpD) / BW = mg/kg-day
3) $CDI_{\text{sw ingestion carcinogenic}}$ = mg/l * EF * SwIR * ED * FI / BW / AT –c = mg/kg-day
4) $CDI_{\text{sw ingestion non cancer}}$ = mg/l * SwIR* / BW = mg/kg-day
5) $CDI_{\text{inhalation of dust carcinogenic}}$ (1) = mg/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI / BW / AT-c = mg/kg-day
6) $CDI_{\text{inhalation of dust non carcinogenic}}$ (1) = mg/m^3 * Ih-R * (DEP/HpD) * FI / BW / = mg/kg-day
7) $CDI_{\text{ground water ingestion carcinogenic}}$ = mg/l * Gwl * EF * ED * FI / BW / AT-c = mg/l-day
8) $CDI_{\text{ground water ingestion non carcinogenic}}$ = mg/l * Gwl * FI / BW = mg/l-day

(1) dust resuspension mg/ m^3 = mg/kg soil * 0.011mg/ m^3 * 1 kg/1E6 mg

Radionuclides

9) $TI_{\text{soil ingestion}}$ = pCi/gr * 1gr/1000 mg * IR * (DEP/HpD) * EF * ED * FI = pCi
10) $TI_{\text{sw ingestion}}$ = pCi/l * EF * SwIR * ED * FI = pCi
11) $TI_{\text{inhalation of dust}}$ (2) = pCi/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI = pCi
12) $TI_{\text{ground water ingestion}}$ = pCi/l * Gwl * EF * FI * ED = pCi
13 $TExp_{\text{external whole body gamma}}$ =µR/hr * EF * DEP * ED * mrem/µR = mrem

(2) dust resuspension pCi/ m^3 = pCi/g soil * 0.011mg/ m^3 * 1 gr/1000 mg

Middle Canyon Recreational Exposure Scenario—Reasonable Maximum Exposure (continued)

Part 2: Concentrations and Intakes Non Radionuclide and Radionuclide COC's RME Computation

	Exposure Point Concentrations					Chronic Daily Intake—"RME"					Daily Intake—"RME"				
	Soil/Sediment		Surface Water	Ground Water	Air	Soil/Sediment Combined		Surface Water	Ground Water	Air	Soil/Sediment Combined		Surface Water	Ground Water	Air
Chemical Name	mg/kg		µg/l	µg/l	mg/m^3	mg/kg-day		mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day		mg/kg-day	mg/kg-day	mg/kg-day
Arsenic	7.74	0	1.4	0	8.514E-08	7.68249E-09	0	7.3E-09	0	1.5E-11	1.8E-08	0	1.70652E-08	0	3.45937E-11
Uranium	28.2	0	147		3.102E-07	2.79905E-08	0	7.7E-07		5.4E-11	6.5E-08	0	1.79185E-06	0	1.26039E-10

	Exposure Point Concentrations					Period Intake (Exposure)					
	Soil/Sediment	Surface Water	Ground Water	Air	gamma	Soil/Sediment		Surface Water	Ground Water	Air	gamma
Radionuclide Name	pCi/gr	pCi/l	pCi/l	pCi/m^3	µR/hr	pCi		pCi	pCi	pCi	mrem
Uranium-234	9.19	45.60		1.0E-04		13.75	0	359.10		2.7E-02	
Uranium-235+D	0.43	1.10		4.7E-06		0.64	0	8.66		1.2E-03	
Uranium-238+D	9.10	52.40		1.0E-04		13.62	0	412.65		2.6E-02	
External gamma				0	29.4						9.261

Middle Canyon Recreational Exposure Scenario—Reasonable Maximum Exposure (continued)

Part 3: Risks & HQ's Non Radionuclides, Risks for Radionuclides RME Computation

	Cancer Risk					Non Cancer Hazard Indicies				
	Ingestion		Inhalation		Sum	Ingestion		Inhalation		
	CDI	Cancer	CDI	Cancer	Cancer	Daily Intake		Daily Intake		Sum
Chemical	mg/kg-day	Risk	mg/kg-day	Risk	Risk	mg/kg-day	HI	mg/kg-day	HI	HI
Arsenic	1.5E-08	2.2E-08	1.5E-11	2.2E-10	2.3E-08	3.5E-08	1.2E-04	3.5E-11	0.0E+00	1.2E-04
Uranium	8.0E-07	0.0E+00	5.4E-11	0.0E+00	0.0E+00	1.9E-06	6.2E-04	1.3E-10	0.0E+00	6.2E-04
Summation		2.2E-08		2.2E-10	2.3E-08		1.2E-04		0.0E+00	1.2E-04

	Ingestion		Inhalation		External		External		External	
		Cancer		Cancer	95% UCL	Risk	95% UCL	Risk	95% UCL	Risk
Radionuclide Name	Total pCi	Risk	Total pCi	Risk	pCi/gr **-Soil**	**Soil**	pCi/gr - **Sediment**	**Sediment**	mrem/period	gamma
Uranium-234	3.7E+02	2.6E-08	2.7E-02	3.0E-10	9.2E+00	6.7E-11	0.0E+00	0.0E+00		
Uranium-235+D	9.3E+00	6.7E-10	1.2E-03	1.2E-11	4.3E-01	6.7E-09	0.0E+00	0.0E+00		
Uranium-238+D	4.3E+02	3.7E-08	2.6E-02	2.5E-10	9.1E+00	3.0E-08	0.0E+00	0.0E+00		
External gamma	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
									9.261	7.4E-06
Summation		*6.4E-08*		*5.6E-10*		3.7E-08		0.0E+00		

Dose & Dose to Risk Assessment	Ingestion		Inhalation		External	
	pCi/year	mrem/year	pCi/year	mrem/year	mrem/year	Total
Mill tailings	2.7E+01	7.6E-03	1.8E-03	2.3E-04	0.31	0.32
30 year CA Risk =		*1.8E-08*		*1.4E-09*	*7.4E-06*	*7.4E-06*

Note: Ingestion and inhalation dose evaluations were based on a Monticello mill tailing specific dose conversion factor based on weighted radionuclide content and indexed to Ra-226. Ra-226 has been eliminated as a COPC because of the reduction to nondetectable levels in ground water and the remediation that was complete on the surface soils. Therefore, new dose conversion factors for ingestion and inhalation were used for the remaining COCs.
Dose from external gamma was estimated by the same method as the original risk assessment using measured µR/hr measurements.

Middle Canyon Recreational Exposure Scenario—Central Tendency

Description: A recreational exposure scenario in which exposure occurs through periodic visits to the area
Pathways include: incidental ingestion of soils and sediments, incidental ingestion of surface water, inhalation of particulates and direct gamma

Part 1: Exposure Factors and Equations

Middle Canyon Recreational Exposure Factors

Factor	Abbreviation	Units	Parameters *Central Tendency*	RME
Exposure Frequency	EF	days/year	14	21
Daily Exposure Period	DEP	hours/day	0.25	0.5
Exposure Duration	ED	years	9	30
Averaging Time-Cancer	AT-c	days	25550	25550
Averaging Time-Non Cancer	AT-NC	days	365	365
Soil-Sediment Ingestion Rate	IR	mg/day	59	114
Fraction Intake From Source	FI	fraction	0.5	1
Inhalation Rate	Ihl	m^3/day	20	20
Surface Water Ingestion Rate	Swl	l/day	0.004	0.013
Ground Water Ingestion Rate[1]	Gwl	l/day	1.4	2
Body Weight	BW	kg	70	59
Hours per Day	HpD	hr/day	24	24
Conversion-solids	Con-s	mg/kg	1.00E+06	1.00E+06
Conversion -water	Con-w	ug/mg	1000	1000
Conversion - solids rad	Con-sr	mg/gr	1000	1000
µR/mrem	Con-e:d	µR/mrem	1.00E+03	1.00E+03
gamma exposure fraction	gef	fyear exposed	0.000399543	0.00119863
gamma shield and roughness factor	Se	ftransmitted	0.5	0.8

[1] Ground water consumption is not segment specific - user ensure continuity (See Residential Consumption)

Equations

Non Radionuclides

1) $CDI_{\text{soil ingestion carcinogenic}}$ = mg/kg * 1 kg/1E 6 mg * EF * IR* (DEP/HpD) * ED * FI / BW / AT –c = mg/kg-day
2) $CDI_{\text{soil ingestion non cancer}}$ = mg/kg * 1kg/1E 6 mg * IR* (DEP/HpD) * EF/ AT_{-NC} BW = mg/kg-day
3) $CDI_{\text{sw ingestion carcinogenic}}$ = mg/l * EF * SwIR * ED * FI / BW / AT –c = mg/kg-day
4) $CDI_{\text{sw ingestion non cancer}}$ = mg/l * SwIR* * EF/ AT_{-NC} / BW = mg/kg-day
5) $CDI_{\text{inhalation of dust carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI / BW / AT-c = mg/kg-day
6) $CDI_{\text{inhalation of dust non carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * (DEP/HpD) ** EF/ AT_{-NC} * FI / BW / = *mg/kg-day*
7) $CDI_{\text{ground water ingestion carcinogenic}}$ = mg/l * Gwl * EF * ED * FI / BW / AT-c = mg/l-day
8) $CDI_{\text{ground water ingestion non carcinogenic}}$ = mg/l * Gwl * EF/ AT_{-NC} * FI / BW = mg/l-day

[(1)] dust resuspension mg/m^3 = mg/kg soil * 0.011mg/m^3 * 1 kg/1E6 mg

Radionuclides

9) $TI_{\text{soil ingestion}}$ = pCi/gr * 1gr/1000 mg * IR * (DEP/HpD) * EF * ED * FI = pCi
10) $TI_{\text{sw ingestion}}$ = pCi/l * EF * SwIR * ED * FI = pCi
11) $TI_{\text{inhalation of dust}}$ [(2)] = pCi/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI = pCi
12) $TI_{\text{ground water ingestion}}$ = pCi/l * Gwl * EF * FI * ED = pCi
13 $TExp_{\text{external whole body gamma}}$ = uR/hr * EF * DEP * ED * mrem/µR = mrem

[(2)] dust resuspension pCi/ m^3 = pCi/g soil * 0.011mg/ m^3 * 1 gr/1000 mg

Middle Canyon Recreational Exposure Scenario—Central Tendency (continued)

Part 2: Concentrations and Intakes Non Radionuclide and Radionuclide COC's CT Computation

	Exposure Point Concentrations				Chronic Daily Intake—"CT"					Daily Intake—"CT"				
Chemical Name	Soil/Sediment	Surface Water	Ground Water	Air	Soil/Sediment Combined	Surface Water	Ground Water	Air		Soil/Sediment Combined	Surface Water	Ground Water	Air	
	mg/kg	µg/l	µg/l	mg/m^3	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day		mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	
Arsenic	7.74	1.4		8.514E-08	1.67561E-10	0 2.05479E-10		0 1.24961E-12		1.30325E-09	0 1.59817E-09		0	4.85959E-12
Uranium	28.2	147		3.102E-07	6.10494E-10	0 2.15753E-08		4.55284E-12		4.74829E-09	0 1.67808E-07		0	1.77055E-11

	Exposure Point Concentrations					Period Intake (Exposure)					
	Soil/Sediment	Surface Water	Ground Water	Air	gamma	Soil/Sediment		Surface Water	Ground Water	Air	gamma
Radionuclide Name	*pCi/gr*	*pCi/l*	*pCi/l*	*pCi/m^3*	*uR/hr*	pCi		pCi	pCi	pCi	mrem
Uranium-234	9.19	45.60		1.0E-04		0.97	0	11.97		2.7E-03	
Uranium-235+D	0.43	1.10		4.7E-06		0.04	0	0.29		1.2E-04	
Uranium-238+D	9.10	52.40		1.0E-04		0.96	0	13.76		2.6E-03	
External gamma	0				29.4						0.9261

Middle Canyon Recreational Exposure Scenario—Central Tendency (continued)

Part 3: Risks and HQ's Non Radionuclides, Risks for Radionuclides CT Computation

	Cancer Risk[a]					Non Cancer Hazard Indicies[b]				
	Ingestion		Inhalation		Sum	Ingestion		Inhalation		
	CDI	Cancer	CDI	Cancer	Cancer	Daily Intake		Daily Intake		Sum
Chemical	mg/kg-day	Risk	mg/kg-day	Risk	Risk	mg/kg-day	HI	mg/kg-day	HI	HI
Arsenic	3.7E-10	5.6E-10	1.2E-12	2.3E-11	5.8E-10	2.9E-09	9.7E-06	4.9E-12	0.0E+00	9.7E-06
Uranium	2.2E-08	0.0E+00	4.6E-12	0.0E+00	0.0E+00	1.7E-07	5.8E-05	1.8E-11	0.0E+00	5.8E-05
Summation		5.6E-10		2.3E-11	5.8E-10		6.7E-05		0.0E+00	6.7E-05

	Ingestion		Inhalation		External		External		External	
		Cancer		Cancer	95% UCL	Risk	95% UCL	Risk	95% UCL	Risk
Radionuclide Name	Total pCi	Risk	Total pCi	Risk	pCi/gr **-Soil**	**Soil**	pCi/gr - **Sediment**	**Sediment**	mrem/period	gamma
Uranium-234	1.3E+01	9.1E-10	2.7E-03	3.0E-11	9.2E+00	4.2E-12	0.0E+00	0.0E+00		
Uranium-235+D	3.3E-01	2.4E-11	1.2E-04	1.2E-12	4.3E-01	4.2E-10	0.0E+00	0.0E+00		
Uranium-238+D	1.5E+01	1.3E-09	2.6E-03	2.5E-11	9.1E+00	1.9E-09	0.0E+00	0.0E+00		
External gamma	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
									0.9261	7.4088E-07
Summation		2.2E-09		5.6E-11		2.3E-09		0.0E+00		

Dose and Dose to Risk Assessment	Ingestion		Inhalation		External	
	pCi/year	mrem/year	pCi/year	mrem/year	mrem/year	Total
Mill tailings	3.1E+00	8.8E-04	6.0E-04	7.5E-05	0.10	0.10
30 year CA Risk =		*6.1E-10*		*1.4E-10*	*7.4E-07*	*7.4E-07*

[a]Cancer risk is estimated as follows: CDI × slope factor. The slope factor quantifies toxicity, and it is obtained from the EPA literature (primary source is the Integrated Risk Information System or IRIS). The result is a unitless probability of added cancer risk.
[b]The noncancer hazard index (HI) is the sum of individual hazard quotients (HQ): $HI = HQ_1 + HQ_2 + \ldots HQ_n$. HQ = CDI/Reference dose. Reference dose or RfD is obtained from EPA literature such as IRIS. HI is a unitless, numeric value used to quantify the potential for noncarcinogenic negative health impacts.

Note: Ingestion and inhalation dose evaluations were based on a Monticello mill tailing specific dose conversion factor based on weighted radionuclide content and indexed to Ra-226. Ra-226 has been eliminated as a COPC because of the reduction to nondetectable levels in ground water and the remediation that was complete on the surface soils. Therefore, new dose conversion factors for ingestion and inhalation were used for the remaining COCs.
Dose from external gamma was estimated by the same method as the original risk assessment using measured µR/hr measurements

Upper Canyon Recreational Exposure Scenario—Reasonable Maximum Exposure

Description: A recreational exposure scenario in which exposure occurs through periodic visits to the area
Pathways include: incidental ingestion of soils and sediments, incidental ingestion of surface water, inhalation of particulates and direct gamma

Part 1: Exposure Factors and Equations

Upper Canyon Recreational Exposure Factors

Factor	Abbreviation	Units	Parameters: Central Tendency	Parameters: *RME*
Exposure Frequency	EF	days/year	90	175
Daily Exposure Period	DEP	hours/day	0.5	0.75
Exposure Duration	ED	years	9	30
Averaging Time-Cancer	AT-c	days	25550	25550
Averaging Time-Non Cancer	AT-NC	days	365	365
Soil-Sediment Ingestion Rate	IR	mg/day	59	114
Fraction Intake From Source	FI	fraction	0.5	1
Inhalation Rate	Ihl	m^3/day	20	20
Surface Water Ingestion Rate	Swl	l/day	0.008	0.019
Ground Water Ingestion Rate[1]	Gwl	l/day	1.4	2
Body Weight	BW	kg	70	59
Hours per Day	HpD	hr/day	24	24
Conversion-solids	Con-s	mg/kg	1.00E+06	1.00E+06
Conversion -water	Con-w	µg/mg	1000	1000
Conversion - solids rad	Con-sr	mg/gr	1000	1000
µR/mrem	Con-e:d	µR/mrem	1.00E+03	1.00E+03
gamma exposure fraction	gef	fyear exposed	0.005136986	0.01498288
gamma shield & roughness factor	Se	ftransmitted	0.5	0.8

[1] Ground water consumption is not segment specific - user ensure continuity (See Residential Consumption)

Equations

Non Radionuclides

1) $CDI_{\text{soil ingestion carcinogenic}}$ = mg/kg * 1 kg/1E 6 mg * EF * IR* (DEP/HpD) * ED * FI / BW / AT –c = mg/kg-day
2) $CDI_{\text{soil ingestion non cancer}}$ = mg/kg * 1kg/1E 6 mg * IR* (DEP/HpD) * EF/ AT_{-NC} BW = mg/kg-day
3) $CDI_{\text{sw ingestion carcinogenic}}$ = mg/l * EF * SwIR * ED * FI / BW / AT –c = mg/kg-day
4) $CDI_{\text{sw ingestion non cancer}}$ = mg/l * SwIR* * EF/ AT_{-NC} / BW = mg/kg-day
5) $CDI_{\text{inhalation of dust carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI / BW / AT-c = mg/kg-day
6) $CDI_{\text{inhalation of dust non carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * (DEP/HpD) ** EF/ AT_{-NC} * FI / BW / = mg/kg-day
7) $CDI_{\text{ground water ingestion carcinogenic}}$ = mg/l * Gwl * EF * ED * FI / BW / AT-c = mg/l-day
8) $CDI_{\text{ground water ingestion non carcinogenic}}$ = mg/l * Gwl * EF/ AT_{-NC} * FI / BW = mg/l-day

[(1)] dust resuspension mg/m^3 = mg/kg soil * 0.011mg/ m^3 * 1 kg/1E6 mg

Radionuclides

9) $TI_{\text{soil ingestion}}$ = pCi/gr * 1gr/1000 mg * IR * (DEP/HpD) * EF * ED * FI = pCi
10) $TI_{\text{sw ingestion}}$ = pCi/l * EF * SwIR * ED * FI = pCi
11) $TI_{\text{inhalation of dust}}$ [(2)] = pCi/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI = pCi
12) $TI_{\text{ground water ingestion}}$ = pCi/l * Gwl * EF * FI * ED = pCi
13 $TExp_{\text{external whole body gamma}}$ = µR/hr * EF * DEP * ED * mrem/µR = mrem

[(2)] dust resuspension pCi/m^3 = pCi/g soil * 0.011mg/ m^3 * 1 gr/1000 mg

Upper Canyon Recreational Exposure Scenario—Reasonable Maximum Exposure (continued)

Part 2: Concentrations and Intakes Non Radionuclide and Radionuclide COC's RME Computation

	Exposure Point Concentrations				Chronic Daily Intake - "RME"					Daily Intake - "RME"				
	Soil/Sediment	Surface Water	Ground Water	Air	Soil/Sediment Combined		Surface Water	Ground Water	Air	Soil/Sediment Combined		Surface Water	Ground Water	Air
Chemical Name	mg/kg	µg/l	µg/l	mg/m^3	mg/kg-day		mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day		mg/kg-day	mg/kg-day	mg/kg-day
Arsenic	7.84	1.5	0	8.624E-08	9.72719E-08	0	9.7951E-08	0	1.8772E-10	2.2697E-07	0	2.28552E-07	0	4.38008E-10
Uranium	26.3	188		2.893E-07	3.26307E-07	0	1.22765E-05		6.2972E-10	7.6138E-07	0	2.86452E-05	0	1.46934E-09

	Exposure Point Concentrations					Period Intake (Exposure)					
	Soil/Sediment	Surface Water	Ground Water	Air	gamma	Soil/Sediment		Surface Water	Ground Water	Air	gamma
Radionuclide Name	pCi/gr	pCi/l	pCi/l	pCi/m^3	µR/hr	pCi		pCi	pCi	pCi	mrem
Uranium-234	8.03	58.70		8.8E-05		150.19	0	5778.3		0.29	
Uranium-235+D	0.429	1.40		4.7E-06		8.02	0	137.8		0.02	
Uranium-238+D	8.21	69.10		9.0E-05		153.55	0	6802.0		0.30	
External gamma					34.2						134.6625

Upper Canyon Recreational Exposure Scenario—Reasonable Maximum Exposure (*continued*)

Part 3: Risks and HQ's Non Radionuclides, Risks for Radionuclides RME Computation

	Cancer Risk					Non Cancer Hazard Indicies				
	Ingestion		Inhalation		Sum	Ingestion		Inhalation		
	CDI	Cancer	CDI	Cancer	Cancer	Daily Intake		Daily Intake		Sum
Chemical	mg/kg-day	Risk	mg/kg-day	Risk	Risk	mg/kg-day	HI	mg/kg-day	HI	HI
Arsenic	2.0E-07	2.9E-07	1.9E-10	2.8E-09	3.0E-07	4.6E-07	1.5E-03	4.4E-10	0.0E+00	1.5E-03
Uranium	1.3E-05	0.0E+00	6.3E-10	0.0E+00	0.0E+00	2.9E-05	9.8E-03	1.5E-09	4.9E-07	9.8E-03
Summation		2.9E-07		2.8E-09	3.0E-07		1.1E-02		4.9E-07	1.1E-02

	Ingestion		Inhalation		External		External		External	
		Cancer		Cancer	95% UCL	Risk	95% UCL	Risk	95% UCL	Risk
Radionuclide Name	Total pCi	Risk	Total pCi	Risk	pCi/gr **-Soil**	**Soil**	pCi/gr - **Sediment**	**Sediment**	mrem/period	gamma
Uranium-234	5.9E+03	4.2E-07	2.9E-01	3.3E-09	8.0E+00	7.3E-10	0.0E+00	0.0E+00		
Uranium-235+D	1.5E+02	1.0E-08	1.5E-02	1.6E-10	4.3E-01	8.4E-08	0.0E+00	0.0E+00		
Uranium-238+D	7.0E+03	6.1E-07	3.0E-01	2.8E-09	8.2E+00	3.4E-07	0.0E+00	0.0E+00		
External gamma	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
									134.6625	1.1E-04
Summation		1.0E-06		6.2E-09		4.2E-07		0.0E+00		

Dose and Dose to Risk Assessment	Ingestion		Inhalation		External	
	pCi/year	mrem/year	pCi/year	mrem/year	mrem/year	Total
Mill tailings	4.3E+02	1.2E-01	2.0E-02	2.5E-03	4.49	4.61
30 year CA Risk =		*2.8E-07*		*1.6E-08*	*1.1E-04*	*1.1E-04*

Note: Ingestion and inhalation dose evaluations were based on a Monticello mill tailing specific dose conversion factor based on weighted radionuclide content and indexed to Ra-226. Ra-226 has been eliminated as a COPC because of the reduction to nondetectable levels in ground water and the remediation that was complete on the surface soils. Therefore, new dose conversion factors for ingestion and inhalation were used for the remaining COCs.
Dose from external gamma was estimated by the same method as the original risk assessment using measured μR/hr measurements.

Upper Canyon Recreational Exposure Scenario—Central Tendency

Description: A recreational exposure scenario in which exposure occurs through periodic visits to the area
Pathways include: incidental ingestion of soils and sediments, incidental ingestion of surface water, inhalation of particulates and direct gamma

Part 1: Exposure Factors and Equations

Upper Canyon Recreational Exposure Factors

Factor	Abbreviation	Units	Parameters *Central Tendency*	Parameters RME
Exposure Frequency	EF	days/year	90	175
Daily Exposure Period	DEP	hours/day	0.5	0.75
Exposure Duration	ED	years	9	30
Averaging Time-Cancer	AT-c	days	25550	25550
Averaging Time-Non Cancer	AT-NC	days	365	365
Soil-Sediment Ingestion Rate	IR	mg/day	59	114
Fraction Intake From Source	FI	fraction	0.5	1
Inhalation Rate	Ihl	m^3/day	20	20
Surface Water Ingestion Rate	Swl	l/day	0.008	0.019
Ground Water Ingestion Rate[1]	Gwl	l/day	1.4	2
Body Weight	BW	kg	70	59
Hours per Day	HpD	hr/day	24	24
Conversion-solids	Con-s	mg/kg	1.00E+06	1.00E+06
Conversion -water	Con-w	µg/mg	1000	1000
Conversion - solids rad	Con-sr	mg/gr	1000	1000
µR/mrem	Con-e:d	µR/mrem	1.00E+03	1.00E+03
gamma exposure fraction	gef	fyear exposed	0.005136986	0.01498288
gamma shield and roughness factor	Se	ftransmitted	0.5	0.8

[1] Ground water consumption is not segment specific - user ensure continuity (See Residential Consumption)

Equations

Non Radionuclides

1) $CDI_{\text{soil ingestion carcinogenic}}$ = mg/kg * 1 kg/1E 6 mg * EF * IR* (DEP/HpD) * ED * FI / BW / AT -c = mg/kg-day
2) $CDI_{\text{soil ingestion non cancer}}$ = mg/kg * 1kg/1E 6 mg * IR* (DEP/HpD) * EF/ AT_{-NC} BW = mg/kg-day
3) $CDI_{\text{sw ingestion carcinogenic}}$ = mg/l * EF * SwIR * ED * FI / BW / AT -c = mg/kg-day
4) $CDI_{\text{sw ingestion non cancer}}$ = mg/l * SwIR* * EF/ AT_{-NC} / BW = mg/kg-day
5) $CDI_{\text{inhalation of dust carcinogenic}}$ (1) = mg/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI / BW / AT-c = mg/kg-day
6) $CDI_{\text{inhalation of dust non carcinogenic}}$ (1) = mg/m^3 * Ih-R * (DEP/HpD) ** EF/ AT_{-NC} * FI / BW / = mg/kg-day
7) $CDI_{\text{ground water ingestion carcinogenic}}$ = mg/l * Gwl * EF * ED * FI / BW / AT-c = mg/l-day
8) $CDI_{\text{ground water ingestion non carcinogenic}}$ = mg/l * Gwl * EF/ AT_{-NC} * FI / BW = mg/l-day

(1) dust resuspension mg/m^3 = mg/kg soil * 0.011mg/ m^3 * 1 kg/1E6 mg

Radionuclides

9) $TI_{\text{soil ingestion}}$ = pCi/gr * 1gr/1000 mg * IR * (DEP/HpD) * EF * ED * FI = pCi
10) $TI_{\text{sw ingestion}}$ = pCi/l * EF * SwIR * ED * FI = pCi
11) $TI_{\text{inhalation of dust}}$ (2) = pCi/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI = pCi
12) $TI_{\text{ground water ingestion}}$ = pCi/l * Gwl * EF * FI * ED = pCi
13 $TExp_{\text{external whole body gamma}}$ = µR/hr * EF * DEP * ED * mrem/µR = mrem

(2) dust resuspension pCi/m^3 = pCi/g soil * 0.011mg/ m^3 * 1 gr/1000 mg

Upper Canyon Recreational Exposure Scenario—Central Tendency (continued)

Part 2: Concentrations and Intakes Non Radionuclide and Radionuclide COC's CT Computation

	Exposure Point Concentrations					Chronic Daily Intake—"CT"					Daily Intake—"CT"				
	Soil/Sediment		Surface Water	Ground Water	Air	Soil/Sediment Combined		Surface Water	Ground Water	Air	Soil/Sediment Combined		Surface Water	Ground Water	Air
Chemical Name	mg/kg	mg/kg	µg/l	µg/l	mg/m^3	mg/kg-day		mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day		mg/kg-day	mg/kg-day	mg/kg-day
Arsenic	7.84	0	1.5	0	8.624E-08	2.182E-09	0	2.83058E-09	0	8.137E-12	1.697E-08	0	2.20157E-08	0	1.26575E-10
Uranium	26.3	0	188		2.893E-07	7.32E-09	0	3.54767E-07	0	2.7296E-11	5.694E-08	0	2.7593E-06	0	4.24609E-10

	Exposure Point Concentrations						Period Intake (Exposure)					
	Soil/Sediment		Surface Water	Ground Water	Air	gamma	Soil/Sediment	0	Surface Water	Ground Water	Air	gamma
Radionuclide Name	pCi/gr	pCi/gr	pCi/l	pCi/l	pCi/m^3	µR/hr	pCi	pCi	pCi	pCi	pCi	mrem
Uranium-234	8.03	0	58.7		0.00008833		3.997434375	0	198.1125		0.0298114	
Uranium-235+D	0.429	0	1.4		0.000004719		0.213561563	0	4.725		0.0015927	
Uranium-238+D	8.21	0	69.1		0.00009031		4.087040625	0	233.2125		0.0304796	
External gamma	0					34.2						13.851

Upper Canyon Recreational Exposure Scenario—Central Tendency (continued)

Part 3: Risks and HQ's Non Radionuclides, Risks for Radionuclides RME Computation

	Cancer Risk[a]					Non Cancer Hazard Indicies[b]				
	Ingestion		Inhalation		Sum	Ingestion		Inhalation		
	CDI	Cancer	CDI	Cancer	Cancer	Daily Intake		Daily Intake		Sum
Chemical	mg/kg-day	Risk	mg/kg-day	Risk	Risk	mg/kg-day	HI	mg/kg-day	HI	HI
Arsenic	*5.0E-09*	*7.5E-09*	*8.1E-12*	*2.3E-11*	*7.5E-09*	*3.9E-08*	1.3E-04	1.3E-10	0.0E+00	1.3E-04
Uranium	3.6E-07	0.0E+00	2.7E-11	0.0E+00	0.0E+00	2.8E-06	9.4E-04	4.2E-10	1.4E-07	9.4E-04
Summation		7.5E-09		2.3E-11	7.5E-09		1.1E-03		0.0E+00	1.1E-03

	Ingestion		Inhalation		External		External		External	
		Cancer		Cancer	95% UCL	Risk	95% UCL	Risk	95% UCL	Risk
Radionuclide Name	Total pCi	Risk	Total pCi	Risk	pCi/gr **-Soil**	**Soil**	pCi/gr **- Sediment**	**Sediment**	mrem/period	gamma
Uranium-234	2.0E+02	1.4E-08	3.0E-02	3.4E-10	8.0E+00	4.7E-11	0.0E+00	0.0E+00		
Uranium-235+D	4.9E+00	3.5E-10	1.6E-03	1.6E-11	4.3E-01	5.4E-09	0.0E+00	0.0E+00		
Uranium-238+D	2.4E+02	2.1E-08	3.0E-02	2.8E-10	8.2E+00	1.0E-07	0.0E+00	0.0E+00		
External gamma	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
									13.851	1.1081E-05
Summation		3.5E-08		6.4E-10		1.1E-07		0.0E+00		
								1.1E-07		

Dose and Dose to Risk Assessment	Ingestion		Inhalation		External	
	pCi/year	mrem/year	pCi/year	mrem/year	mrem/year	Total
Mill tailings	4.9E+01	1.4E-02	6.9E-03	8.6E-04	1.54	1.55
30 year CA Risk =		*9.7E-09*		*1.6E-09*	*1.1E-05*	*1.1E-05*

[a]Cancer risk is estimated as follows: CDI × slope factor. The slope factor quantifies toxicity, and it is obtained from the EPA literature (primary source is the Integrated Risk Information System or IRIS). The result is a unitless probability of added cancer risk.
[b]The noncancer hazard index (HI) is the sum of individual hazard quotients (HQ): $HI = HQ_1 + HQ_2 + \ldots HQ_n$. HQ = CDI/Reference dose. Reference dose or RfD is obtained from EPA literature such as IRIS. HI is a unitless, numeric value used to quantify the potential for noncarcinogenic negative health impacts.

Note: Ingestion and inhalation dose evaluations were based on a Monticello mill tailing specific dose conversion factor based on weighted radionuclide content and indexed to Ra-226. Ra-226 has been eliminated as a COPC because of the reduction to nondetectable levels in ground water and the remediation that was complete on the surface soils. Therefore, new dose conversion factors for ingestion and inhalation were used for the remaining COCs.
Dose from external gamma was estimated by the same method as the original risk assessment using measured µR/hr measurements.

OU III Ground Water Consumption From the Alluvial Aquifer—Reasonable Maximum Exposure Assumptions Near-Term Exposure

Description: A ground water consumption exposure scenario involving routine intake affected water from domestic use.
Pathways include: Routine ingestion of ground water.

Part 1: Exposure Factors and Equations

Residential Ground Water Consumption Only

Factor	Abbreviation	Units	Parameters Central Tendency	*RME*
Exposure Frequency	EF	days/year	325	350
Daily Exposure Period	DEP	hours/day	0.68	1.03
Exposure Duration	ED	years	9	30
Averaging Time-Cancer	AT-c	days	25550	25550
Averaging Time-Non Cancer	AT-NC	days	365	365
Soil-Sediment Ingestion Rate	IR	mg/day	59	114
Fraction Intake From Source	FI	fraction	0.5	1
Inhalation Rate	Ihl	m^3/day	20	20
Surface Water Ingestion Rate	Swl	l/day	0.25	0.33
Ground Water Ingestion Rate[1]	Gwl	l/day	1.4	2
Body Weight	BW	kg	70	59
Hours per Day	HpD	hr/day	24	24
Conversion-solids	Con-s	mg/kg	1.00E+06	1.00E+06
Conversion -water	Con-w	µg/mg	1000	1000
Conversion - solids rad	Con-sr	mg/gr	1000	1000
mrem/µR	Con-e:d	mrem/µR	1.00E+03	1.00E+03
gamma exposure fraction	gef	fyear exposed	0.025228311	0.04115297
gamma shield and roughness factor	Se	ftransmitted	0.5	0.8

[1] Ground water consumption is not segment specific - user ensure continuity (See Residential Consumption)

Equations

Non Radionuclides

1) $CDI_{\text{soil ingestion carcinogenic}}$ = mg/kg * 1 kg/1E 6 mg * EF * IR* (DEP/HpD) * ED * FI / BW / AT -c = mg/kg-day
2) $CDI_{\text{soil ingestion non cancer}}$ = mg/kg * 1kg/1E 6 mg * IR* (DEP/HpD) / BW = mg/kg-day
3) $CDI_{\text{sw ingestion carcinogenic}}$ = mg/l * EF * SwIR * ED * FI / BW / AT -c = mg/kg-day
4) $CDI_{\text{sw ingestion non cancer}}$ = mg/l * SwIR* / BW = mg/kg-day
5) $CDI_{\text{inhalation of dust carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI / BW / AT-c = mg/kg-day
6) $CDI_{\text{inhalation of dust non carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * (DEP/HpD) * FI / BW / = mg/kg-day
7) $CDI_{\text{ground water ingestion carcinogenic}}$ = mg/l * Gwl * EF * ED * FI / BW / AT-c = mg/l-day
8) $CDI_{\text{ground water ingestion non carcinogenic}}$ = mg/l * Gwl * FI / BW = mg/l-day

[(1)] dust resuspension mg/ m^3 = mg/kg soil * 0.011mg/ m^3 * 1 kg/1E6 mg

Radionuclides

9) $TI_{\text{soil ingestion}}$ = pCi/gr * 1gr/1000 mg * IR * (DEP/HpD) * EF * ED * FI = pCi
10) $TI_{\text{sw ingestion}}$ = pCi/l * EF * SwIR * ED * FI = pCi
11) $TI_{\text{inhalation of dust}}$ [(2)] = pCi/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI = pCi
12) $TI_{\text{ground water ingestion}}$ = pCi/l * Gwl * EF * FI * ED = pCi
13) $TExp_{\text{external whole body gamma}}$ = µR/hr * EF * DEP * ED * mrem/µR = mrem

[(2)] dust resuspension pCi/m^3 = pCi/g soil * 0.011mg/m^3 * 1 gr/1000 mg

OU III Ground Water Consumption From the Alluvial Aquifer—Reasonable Maximum Exposure Assumptions Near-Term Exposure (continued)

Part 2: Concentrations and Intakes Non Radionuclide and Radionuclide COC's RME Computation

	Exposure Point Concentrations					Chronic Daily Intake—"RME"					Daily Average Intake—"RME"				
	Soils	Sediment	Surface Water	Ground Water	Air	Soils	Sediment	Surface Water	Ground Water	Air	Soils	Sediment	Surface Water	Ground Water	Air
Chemical	mg/kg	mg/kg	µg/l	µg/l	mg/m^3	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day
Arsenic	0	0		16.5	0	0	0	0	2.3E-04	0	0	0	0	5.4E-04	0
Manganese (nonfood)				1.3					1.8E-05					4.2E-05	
Molybdenum				25					3.5E-04					8.1E-04	
Nitrate				8668					1.2E-01					2.8E-01	
Selenium				85					1.2E-03					2.8E-03	
Uranium				317					4.4E-03					1.0E-02	
Vanadium				562					7.8E-03					1.8E-02	

	Exposure Point Concentrations						Period Intake (Exposure)					
	Soils	Sediment	Surface Water	Ground Water	Air	gamma	Soils	Sediment	Surface Water	Ground Water	Air	gamma
Radionuclide Name	pCi/gr	pCi/gr	pCi/l	pCi/l	pCi/m^3	µR/hr	pCi	pCi	pCi	pCi	pCi	mrem
Uranium-234				91.58447					0	1923273.87		
Uranium-235+D				4.9					0	102900		
Uranium-238+D				105.878					0	2223438		
	0			0					0	0		

OU III Ground Water Consumption From the Alluvial Aquifer—Reasonable Maximum Exposure Assumptions Near-Term Exposure(continued)

Part 3: Risks and HQ's Non Radionuclides, Risks for Radionuclides RME Computation

	Cancer Risk[a]					Non Cancer Hazard Indicies[b]				
	Ingestion		Inhalation		Sum	Ingestion		Inhalation		
	CDI	Cancer	CDI	Cancer	Cancer	Daily Intake		Daily Intake		Sum
Chemical	mg/kg-day	Risk	mg/kg-day	Risk	Risk	mg/kg-day	HI	mg/kg-day	HI	HI
Arsenic	2.3E-04	3.4E-04	0.0E+00	0.0E+00	3.4E-04	5.4E-04	1.788	0.0E+00	0.0E+00	1.8
Manganese (nonfood)	1.8E-05	0.0E+00			0.0E+00	4.2E-05	0.002			0.0
Molybdenum	3.5E-04	0.0E+00			0.0E+00	8.1E-04	0.163			0.2
Nitrate	1.2E-01	0.0E+00			0.0E+00	2.8E-01	0.176			0.2
Selenium	1.2E-03	0.0E+00			0.0E+00	2.8E-03	0.553			0.6
Uranium	4.4E-03	0.0E+00			0.0E+00	1.0E-02	3.435			3.4
Vanadium	7.8E-03	0.0E+00			0.0E+00	1.8E-02	2.610			2.6
Summation		3.4E-04		0.0E+00	3.4E-04		8.7		0.0E+00	8.7E+00

	Ingestion		Inhalation		External		External		External	
		Cancer		Cancer	95% UCL	Risk	95% UCL	Risk	95% UCL	Risk
Radionuclide Name	Total pCi	Risk	Total pCi	Risk	pCi/gr -**Soil**	**Soil**	pCi/gr - **Sediment**	**Sediment**	mrem/period	gamma
Uranium-234	1.9E+06	1.4E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
Uranium-235+D	1.0E+05	7.4E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
Uranium-238+D	2.2E+06	1.9E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
Summation		3.4E-04		0.0E+00		0.0E+00		0.0E+00		

Dose and Dose to Risk Assessment	Ingestion		Inhalation		External	
	pCi/year	mrem/year	pCi/year	mrem/year	mrem/year	Total
Mill tailings	1.4E+05	4.0E+01	0.0E+00	0.0E+00	NA	40.18
30 year CA Risk =		*9.3E-05*		*0.0E+00*	*0.0E+00*	*9.3E-05*

[a]Cancer risk is estimated as follows: CDI × slope factor. The slope factor quantifies toxicity, and it is obtained from the EPA literature (primary source is the Integrated Risk Information System or IRIS). The result is a unitless probability of added cancer risk.
[b]The noncancer hazard index (HI) is the sum of individual hazard quotients (HQ): $HI = HQ_1 + HQ_2 + \ldots HQ_n$. HQ = CDI/Reference dose. Reference dose or RfD is obtained from EPA literature such as IRIS. HI is a unitless, numeric value used to quantify the potential for noncarcinogenic negative health impacts.

Note: Ingestion and inhalation dose evaluations were based on a Monticello mill tailing specific dose conversion factor based on weighted radionuclide content and indexed to Ra-226. Ra-226 has been eliminated as a COPC because of the reduction to nondetectable levels in ground water and the remediation that was complete on the surface soils. Therefore, new dose conversion factors for ingestion and inhalation were used for the remaining COCs
Dose from external gamma was estimated by the same method as the original risk assessment using measured μR/hr measurements.

OU III Ground Water Consumption From the Upper Flow System—Central Tendency Assumptions Near Term Exposure

Description: A ground water consumption exposure scenario involving routine intake affected water from domestic use.
Pathways include: Routine ingestion of ground water.

Part 1: Exposure Factors and Equations

Residential G round Water Consumption Only

Factor	Abbreviation	Units	Parameters *Central Tendency*	RME
Exposure Frequency	EF	days/year	325	350
Daily Exposure Period	DEP	hours/day	0.68	1.03
Exposure Duration	ED	years	9	30
Averaging Time-Cancer	AT-c	days	25550	25550
Averaging Time-Non Cancer	AT-NC	days	365	365
Soil-Sediment Ingestion Rate	IR	mg/day	59	114
Fraction Intake From Source	FI	fraction	0.5	1
Inhalation Rate	Ihl	m^3/day	20	20
Surface Water Ingestion Rate	Swl	l/day	0.012	0.026
Ground Water Ingestion Rate[1]	Gwl	l/day	1.4	2
Body Weight	BW	kg	70	59
Hours per Day	HpD	hr/day	24	24
Conversion-solids	Con-s	mg/kg	1.00E+06	1000000
Conversion -water	Con-w	µg/mg	1000	1000
Conversion - solids rad	Con-sr	mg/gr	1000	1000
µR/mrem	Con-e:d	µR/mrem	1.00E+03	1000
gamma exposure fraction	gef	fyear exposed	0.025228311	0.041152968
gamma shield & roughness factor	Se	ftransmitted	0.5	0.8

[1] Ground water consumption is not segment specific - user ensure continuity (See Residential Consumption)

Equations

Non Radionuclides

1) $CDI_{\text{soil ingestion carcinogenic}}$ = mg/kg * 1 kg/1E 6 mg * EF * IR* (DEP/HpD) * ED * FI / BW / AT -c = mg/kg-day
2) $CDI_{\text{soil ingestion non cancer}}$ = mg/kg * 1kg/1E 6 mg * IR* (DEP/HpD) * EF/ AT_{-NC} BW = mg/kg-day
3) $CDI_{\text{sw ingestion carcinogenic}}$ = mg/l * EF * SwIR * ED * FI / BW / AT -c = mg/kg-day
4) $CDI_{\text{sw ingestion non cancer}}$ = mg/l * SwIR* * EF/ AT_{-NC} / BW = mg/kg-day
5) $CDI_{\text{inhalation of dust carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI / BW / AT-c = mg/kg-day
6) $CDI_{\text{inhalation of dust non carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * (DEP/HpD) ** EF/ AT_{-NC} * FI / BW / = mg/kg-day
7) $CDI_{\text{ground water ingestion carcinogenic}}$ = mg/l * Gwl * EF * ED * FI / BW / AT-c = mg/l-day
8) $CDI_{\text{ground water ingestion non carcinogenic}}$ = mg/l * Gwl * EF/ AT_{-NC} * FI / BW = mg/l-day

[(1)] dust resuspension mg/m^3 = mg/kg soil * 0.011mg/m^3 * 1 kg/1E6 mg

Radionuclides

9) $TI_{\text{soil ingestion}}$ = pCi/gr * 1gr/1000 mg * IR * (DEP/HpD) * EF * ED * FI = pCi
10) $TI_{\text{sw ingestion}}$ = pCi/l * EF * SwIR * ED * FI = pCi
11) $TI_{\text{inhalation of dust}}$ [(2)] = pCi/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI = pCi
12) $TI_{\text{ground water ingestion}}$ = pCi/l * Gwl * EF * FI * ED = pCi
13 $TExp_{\text{external whole body gamma}}$ = µR/hr * EF * DEP * ED * mrem/µR = mrem

[(2)] dust resuspension pCi/m^3 = pCi/g soil * 0.011mg/m^3 * 1 gr/1000 mg

OU III Ground Water Consumption From the Upper Flow System—Central Tendency Assumptions Near Term Exposure (continued)

Part 2: Concentrations and Intakes Non Radionuclide and Radionuclide COC's CT Computation

Chemical Name	Exposure Point Concentrations					Chronic Daily Intake—"CT"					Daily Average Intake—"CT"				
	Soils	Sediment	Surface Water	Ground Water	Air	Soils	Sediment	Surface Water	Ground Water	Air	Soils	Sediment	Surface Water	Ground Water	Air
	mg/kg	mg/kg	µg/l	µg/l	mg/m^3	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day
Arsenic				16.5					3.78E-05					2.9E-04	
Manganese (nonfood)				1.3					2.98E-06					2.3E-05	
Molybdenum			0	25	0	0	0	0	5.72E-05	0	0	0	0	4.5E-04	0
Nitrate				8668					1.98E-02					1.5E-01	
Selenium				85					1.95E-04					1.5E-03	
Uranium				317					7.26E-04					5.6E-03	
Vanadium				562					1.29E-03					1.0E-02	

Radionuclide Name	Exposure Point Concentrations						Period Intake (Exposure)					
	Soils	Sediment	Surface Water	Ground Water	Air	gamma	Soils	Sediment	Surface Water	Ground Water	Air	gamma
	pCi/gr	pCi/gr	pCi/l	pCi/l	pCi/m^3	µR/hr	pCi	pCi	pCi	pCi	pCi	mrem
Uranium-234				91.58447						375038.4047		
Uranium-235+D				4.9						20065.5		
Uranium-238+D				105.878						433570.41		
	0			0								

OU III Ground Water Consumption From the Upper Flow System—Central Tendency Assumptions Near Term Exposure (continued)

Part 3: Risks and HQ's Non Radionuclides, Risks for Radionuclides RME Computation

Chemical	Cancer Risk[a] Ingestion CDI mg/kg-day	Ingestion Cancer Risk	Inhalation CDI mg/kg-day	Inhalation Cancer Risk	Sum Cancer Risk	Non Cancer Hazard Indicies[b] Ingestion Daily Intake mg/kg-day	Ingestion HI	Inhalation Daily Intake mg/kg-day	Inhalation HI	Sum HI
Arsenic	3.8E-05	5.7E-05	0.0E+00	0.0E+00	5.7E-05	2.9E-04	1.0	0.0E+00	0.0E+00	1.0
Manganese (nonfood)	3.0E-06	0.0E+00				2.3E-05	0.0			0.0
Molybdenum	5.7E-05	0.0E+00				4.5E-04	0.1			0.1
Nitrate	2.0E-02	0.0E+00				1.5E-01	0.1			0.1
Selenium	1.9E-04	0.0E+00				1.5E-03	0.3			0.3
Uranium	7.3E-04	0.0E+00				5.6E-03	1.9			1.9
Vanadium	1.3E-03	0.0E+00				1.0E-02	1.4			1.4
0							0.0			0.0
Summation	2.2E-02									
		5.7E-05		0.0E+00	5.7E-05		4.8		0.0E+00	**4.8**

Radionuclide Name	Ingestion Total pCi	Ingestion Cancer Risk	Inhalation Total pCi	Inhalation Cancer Risk	External 95% UCL pCi/gr -Soil	External Risk Soil	External 95% UCL pCi/gr - Sediment	External Risk Sediment	External 95% UCL mrem/period	External Risk gamma
Uranium-234	3.8E+05	2.7E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
Uranium-235+D	2.0E+04	1.4E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
Uranium-238+D	4.3E+05	3.8E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
0		0.0E+00								0.0E+00
									0	
Summation									0	
		6.6E-05		0.0E+00		0.0E+00		0.0E+00		

Dose & Dose to Risk Assessment

	Ingestion pCi/year	Ingestion mrem/year	Inhalation pCi/year	Inhalation mrem/year	External mrem/year	Total
Milltailings	9.2E+04	2.6E+01	0.0E+00	0.0E+00	0.00	26.11
30 year CA Risk =		*1.8E-05*		*0.0E+00*	*0.0E+00*	*1.8E-05*

[a]Cancer risk is estimated as follows: CDI × slope factor. The slope factor quantifies toxicity, and it is obtained from the EPA literature (primary source is the Integrated Risk Information System or IRIS). The result is a unitless probability of added cancer risk.
[b]The noncancer hazard index (HI) is the sum of individual hazard quotients (HQ): $HI = HQ_1 + HQ_2 + \ldots HQ_n$. HQ = CDI/Reference dose. Reference dose or RfD is obtained from EPA literature such as IRIS. HI is a unitless, numeric value used to quantify the potential for noncarcinogenic negative health impacts.

Note: Ingestion and inhalation dose evaluations were based on a Monticello mill tailing specific dose conversion factor based on weighted radionuclide content and indexed to Ra-226. Ra-226 has been eliminated as a COPC because of the reduction to nondetectable levels in ground water and the remediation that was complete on the surface soils. Therefore, new dose conversion factors for ingestion and inhalation were used for the remaining COCs.
Dose from external gamma was estimated by the same method as the original risk assessment using measured μR/hr measurements.

End of current text

Long-Term Ground Water Risks

Contaminant Concentrations With Modeled Uranium Concentrations in Ground Water

Concentrations are presented by media as follows: 1) soil/sediment, 2) surface water, and 3) ground water.
Because of its insignificant contribution to the total risks, the beef ingestion scenario was not evaluated as part 0f the risk assessment update.

Concentrations in Soils and Sediments (mg/kg or pCi/gr)

	mg/kg		
Compound	**Lower Canyon**	**Middle Canyon**	**Upper Canyon**
Arsenic	6.96	7.7	7.8
Uranium	18.9	28.2	26.3

	pCi/gr (gamma - uR/hr)		
	Lower Canyon	**Middle Canyon**	**Upper Canyon**
U-234	6.1	9.2	8.0
U-235	0.3	0.4	0.4
U-238	6.1	9.1	8.2
External gamma	28.1	29.4	34.2

Contaminant Concentrations in Surface Water (ug/l or pCi/l)

	µg/l		
Compound	***Lower Canyon***	***Middle Canyon***	***Upper Canyon***
Arsenic	1.1	1.4	1.5
Uranium	89.9	147.0	188.0

	pCi/l		
	Lower Canyon	**Middle Canyon**	**Upper Canyon**
Uranium-234	27.6	45.6	58.7
Uranium-235+D	0.7	1.1	1.4
Uranium-238+D	32.3	52.4	69.1

Contaminant Concentrations With Modeled Uranium Concentrations in Ground Water (continued)

Contaminant Concentrations in Ground Water (µg/l or pCi/l)

Compound	Ground Water Concentration (µg/l)	Background Concentration µg/l	Notes
Arsenic	1.6	1.42	Alluvial well 92-09; October 2002 result; original reference area data
Manganese (nonfood)	218	30.4	Alluvial well 92-09; October 2002 result; original reference area data
Molybdenum	1.7	4.4	Alluvial well 92-09; October 2002 result; original reference area data
Nitrate	54	4444	Alluvial well 92-09; October 2002 result; original reference area data, converted to NO_3 by multiplying by 4.4 assuming the NO_2 +NO_3 is all NO_3
Selenium	0.1	2.06	Alluvial well 92-09; October 2002 result; original reference area data
Uranium	249	4.78	Alluvial well 92-09; October 2002 result; original reference area data
Vanadium	0.3	2.83	Alluvial well 92-09; October 2002 result; original reference area data
	GW Concentration (pCi/l)	**pCi/l**	**Notes**
U-234	72	3.09	Estimated from total U (October 2002 data) based on the isotopic ratios
U-235	3.8	0.191	Estimated from total U (October 2002 data) based on the isotopic ratios
U-238	83.2	1.7	Estimated from total U (October 2002 data) based on the isotopic ratios

Notes: The beef ingestion pathway was not included in the updated risk evaluation because it was found to be insignificant compared to other pathways in the original risk assessment and tissue sampling indicated that the contaminants are not being bioaccumulated.
The air pathway exposure point concentrations are based on contaminant concentrations in soil (see the canyon scenarios).
Estimated isotopic uranium is based on U-234/U-238 ratio of 0.865

OU III Ground Water Consumption From the Alluvial Aquifer—Reasonable Maximum Exposure Assumptions Long-Term Exposure

Description: A ground water consumption exposure scenario involving routine intake affected water from domestic use.

Pathways include: Routine ingestion of ground water.

Part 1: Exposure Factors & Equations

Residential Ground Water Consumption Only

Factor	Abbreviation	Units	Parameters Central Tendency	*RME*
Exposure Frequency	EF	days/year	325	350
Daily Exposure Period	DEP	hours/day	0.68	1.03
Exposure Duration	ED	years	9	30
Averaging Time-Cancer	AT-c	days	25550	25550
Averaging Time-Non Cancer	AT-NC	days	365	365
Soil-Sediment Ingestion Rate	IR	mg/day	59	114
Fraction Intake From Source	FI	fraction	0.5	1
Inhalation Rate	Ihl	m^3/day	20	20
Surface Water Ingestion Rate	Swl	l/day	0.25	0.33
Ground Water Ingestion Rate[1]	Gwl	l/day	1.4	2
Body Weight	BW	kg	70	59
Hours per Day	HpD	hr/day	24	24
Conversion-solids	Con-s	mg/kg	1.00E+06	1.00E+06
Conversion -water	Con-w	µg/mg	1000	1000
Conversion - solids rad	Con-sr	mg/gr	1000	1000
mrem/µR	Con-e:d	mrem/µR	1.00E+03	1.00E+03
gamma exposure fraction	gef	fyear exposed	0.025228311	0.04115297
gamma shield and roughness factor	Se	ftransmitted	0.5	0.8

[1] Ground water consumption is not segment specific - user ensure continuity (See Residential Consumption)

Equations

Non Radionuclides

1) $CDI_{\text{soil ingestion carcinogenic}}$ = mg/kg * 1 kg/1E 6 mg * EF * IR* (DEP/HpD) * ED * FI / BW / AT -c = mg/kg-day

2) $CDI_{\text{soil ingestion non cancer}}$ = mg/kg * 1kg/1E 6 mg * IR* (DEP/HpD) / BW = mg/kg-day

3) $CDI_{\text{sw ingestion carcinogenic}}$ = mg/l * EF * SwIR * ED * FI / BW / AT -c = mg/kg-day

4) $CDI_{\text{sw ingestion non cancer}}$ = mg/l * SwIR* / BW = mg/kg-day

5) $CDI_{\text{inhalation of dust carcinogenic}}$ (1) = mg/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI / BW / AT-c = mg/kg-day

6) $CDI_{\text{inhalation of dust non carcinogenic}}$ (1) = mg/m^3 * Ih-R * (DEP/HpD) * FI / BW / = mg/kg-day

7) $CDI_{\text{ground water ingestion carcinogenic}}$ = mg/l * Gwl * EF * ED * FI / BW / AT-c = mg/l-day

8) $CDI_{\text{ground water ingestion non carcinogenic}}$ = mg/l * Gwl * FI / BW = mg/l-day

(1) dust resuspension mg/ m^3 = mg/kg soil * 0.011mg/ m^3 * 1 kg/1E6 mg

Radionuclides

9) $TI_{\text{soil ingestion}}$ = pCi/gr * 1gr/1000 mg * IR * (DEP/HpD) * EF * ED * FI = pCi

10) $TI_{\text{sw ingestion}}$ = pCi/l * EF * SwIR * ED * FI = pCi

11) $TI_{\text{inhalation of dust}}$ (2) = pCi/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI = pCi

12) $TI_{\text{ground water ingestion}}$ = pCi/l * Gwl * EF * FI * ED = pCi

13 $TExp_{\text{external whole body gamma}}$ = µR/hr * EF * DEP * ED * mrem/µR = mrem

(2) dust resuspension pCi/m^3 = pCi/g soil * 0.011mg/m^3 * 1 gr/1000 mg

OU III Ground Water Consumption From the Alluvial Aquifer—Reasonable Maximum Exposure Assumptions Long-Term Exposure (continued)

Part 2: Concentrations and Intakes Non Radionuclide and Radionuclide COC's RME Computation

	Exposure Point Concentrations					Chronic Daily Intake—"RME"					Daily Average Intake—"RME"				
	Soils	Sediment	Surface Water	Ground Water	Air	Soils	Sediment	Surface Water	Ground Water	Air	Soils	Sediment	Surface Water	Ground Water	Air
Chemical	*mg/kg*	*mg/kg*	*µg/l*	*µg/l*	*mg/m³*	*mg/kg-day*	*mg/kg-day*	*mg/kg-day*	*mg/kg-day*	*mg/kg-day*	*mg/kg-day*	*mg/kg-day*	*mg/kg-day*	*mg/kg-day*	*mg/kg-day*
Arsenic	0	0		1.6	0	0	0	0	2.2E-05	0	0	0	0	5.2E-05	0
Manganese (nonfood)				218					3.0E-03					7.1E-03	
Molybdenum				1.7					2.4E-05					5.5E-05	
Nitrate				54					7.5E-04					1.8E-03	
Selenium				0.1					1.4E-06					3.3E-06	
Uranium				249					3.5E-03					8.1E-03	
Vanadium				0.3					4.2E-06					9.8E-06	

	Exposure Point Concentrations						Period Intake (Exposure)					
	Soils	Sediment	Surface Water	Ground Water	Air	gamma	Soils	Sediment	Surface Water	Ground Water	Air	gamma
Radionuclide Name	pCi/gr	pCi/gr	pCi/l	pCi/l	pCi/m³	µR/hr	pCi	pCi	pCi	pCi	pCi	mrem
Uranium-234				71.93859					0	1510710.39		
Uranium-235+D				3.8097					0	80003.7		
Uranium-238+D				83.166					0	1746486		
	0			0					0	0		

OU III Ground Water Consumption From the Alluvial Aquifer—Reasonable Maximum Exposure Assumptions Long-Term Exposure (continued)

Part 3: Risks and HQ's Non Radionuclides, Risks for Radionuclides RME Computation

	Cancer Risk[a]					Non Cancer Hazard Indicies[b]				
	Ingestion		Inhalation		Sum	Ingestion		Inhalation		
	CDI	Cancer	CDI	Cancer	Cancer	Daily Intake		Daily Intake		Sum
Chemical	mg/kg-day	Risk	mg/kg-day	Risk	Risk	mg/kg-day	HI	mg/kg-day	HI	HI
Arsenic	2.2E-05	3.3E-05	0.0E+00	0.0E+00	3.3E-05	5.2E-05	0.173	0.0E+00	0.0E+00	0.2
Manganese (nonfood)	3.0E-03	0.0E+00			0.0E+00	7.1E-03	0.354			0.4
Molybdenum	2.4E-05	0.0E+00			0.0E+00	5.5E-05	0.011			0.0
Nitrate	7.5E-04	0.0E+00			0.0E+00	1.8E-03	0.001			0.0
Selenium	1.4E-06	0.0E+00			0.0E+00	3.3E-06	0.001			0.0
Uranium	3.5E-03	0.0E+00			0.0E+00	8.1E-03	2.698			2.7
Vanadium	4.2E-06	0.0E+00			0.0E+00	9.8E-06	0.001			0.0
Summation		3.3E-05		0.0E+00	3.3E-05		3.2		0.0E+00	3.2E+0

	Ingestion		Inhalation		External		External		External	
		Cancer		Cancer	95% UCL	Risk	95% UCL	Risk	95% UCL	Risk
Radionuclide Name	Total pCi	Risk	Total pCi	Risk	pCi/gr -**Soil**	**Soil**	pCi/gr - **Sediment**	**Sediment**	mrem/period	gamma
Uranium-234	1.5E+06	1.1E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
Uranium-235+D	8.0E+04	5.7E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
Uranium-238+D	1.7E+06	1.5E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
Summation		2.6E-04		0.0E+00		0.0E+00		0.0E+00		

Dose & Dose to Risk Assessment	Ingestion		Inhalation		External	
	pCi/year	mrem/year	pCi/year	mrem/year	mrem/year	Total
Mill tailings	1.1E+05	3.2E+01	0.0E+00	0.0E+00	NA	31.55
30 year CA Risk =		*7.3E-05*		*0.0E+00*	*0.0E+00*	*7.3E-0*

[a]Cancer risk is estimated as follows: CDI × slope factor. The slope factor quantifies toxicity, and it is obtained from the EPA literature (primary source is the Integrated Risk Information System or IRIS). The result is a unitless probability of added cancer risk.
[b]The noncancer hazard index (HI) is the sum of individual hazard quotients (HQ): $HI = HQ_1 + HQ_2 + \ldots HQ_n$. HQ = CDI/Reference dose. Reference dose or RfD is obtained from EPA literature such as IRIS. HI is a unitless, numeric value used to quantify the potential for noncarcinogenic negative health impacts.

Note: Ingestion and inhalation dose evaluations were based on a Monticello mill tailing specific dose conversion factor based on weighted radionuclide content and indexed to Ra-226. Ra-226 has been eliminated as a COPC because of the reduction to nondetectable levels in ground water and the remediation that was complete on the surficial soils. Therefore, new dose conversion factors for ingestion and inhalation were used for the remaining COCs.
Dose from external gamma was estimated by the same method as the original risk assessment using measured µR/hr measurements.

OU III Ground Water Consumption From the Upper Flow System—Central Tendency Assumptions Long-Term Exposure

Description: A ground water consumption exposure scenario involving routine intake affected water from domestic use.
Pathways include: Routine ingestion of ground water.

Part 1: Exposure Factors and Equations

Residential GW Consumption Only

Factor	Abbreviation	Units	Parameters Central Tendency	RME
Exposure Frequency	EF	days/year	325	350
Daily Exposure Period	DEP	hours/day	0.68	1.03
Exposure Duration	ED	years	9	30
Averaging Time-Cancer	AT-c	days	25550	25550
Averaging Time-Non Cancer	AT-NC	days	365	365
Soil-Sediment Ingestion Rate	IR	mg/day	59	114
Fraction Intake From Source	FI	fraction	0.5	1
Inhalation Rate	Ihl	m^3/day	20	20
Surface Water Ingestion Rate	Swl	l/day	0.012	0.026
Ground Water Ingestion Rate[1]	Gwl	l/day	1.4	2
Body Weight	BW	kg	70	59
Hours per Day	HpD	hr/day	24	24
Conversion-solids	Con-s	mg/kg	1.00E+06	1000000
Conversion -water	Con-w	µg/mg	1000	1000
Conversion - solids rad	Con-sr	mg/gr	1000	1000
µR/mrem	Con-e:d	µR/mrem	1.00E+03	1000
gamma exposure fraction	gef	fyear exposed	0.025228311	0.041152968
gamma shield & roughness factor	Se	ftransmitted	0.5	0.8

[1] Ground water consumption is not segment specific - user ensure continuity (See Residential Consumption)

Equations

Non Radionuclides

1) $CDI_{\text{soil ingestion carcinogenic}}$ = mg/kg * 1 kg/1E 6 mg * EF * IR* (DEP/HpD) * ED * FI / BW / AT -c = mg/kg-day
2) $CDI_{\text{soil ingestion non cancer}}$ = mg/kg * 1kg/1E 6 mg * IR* (DEP/HpD) * EF/ AT_{-NC} BW = mg/kg-day
3) $CDI_{\text{sw ingestion carcinogenic}}$ = mg/l * EF * SwIR * ED * FI / BW / AT -c = mg/kg-day
4) $CDI_{\text{sw ingestion non cancer}}$ = mg/l * SwIR* * EF/ AT_{-NC} / BW = mg/kg-day
5) $CDI_{\text{inhalation of dust carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI / BW / AT-c = mg/kg-day
6) $CDI_{\text{inhalation of dust non carcinogenic}}$ [(1)] = mg/m^3 * Ih-R * (DEP/HpD) ** EF/ AT_{-NC} * FI / BW / = mg/kg-day
7) $CDI_{\text{ground water ingestion carcinogenic}}$ = mg/l * Gwl * EF * ED * FI / BW / AT-c = mg/l-day
8) $CDI_{\text{ground water ingestion non carcinogenic}}$ = mg/l * Gwl * EF/ AT_{-NC} * FI / BW = mg/l-day

[(1)] dust resuspension mg/ m^3 = mg/kg soil * 0.011mg/ m^3 * 1 kg/1E6 mg

Radionuclides

9) $TI_{\text{soil ingestion}}$ = pCi/gr * 1gr/1000 mg * IR * (DEP/HpD) * EF * ED * FI = pCi
10) $TI_{\text{sw ingestion}}$ = pCi/l * EF * SwIR * ED * FI = pCi
11) $TI_{\text{inhalation of dust}}$ [(2)] = pCi/m^3 * Ih-R * EF * (DEP/HpD) * ED * FI = pCi
12) $TI_{\text{ground water ingestion}}$ = pCi/l * Gwl * EF * FI * ED = pCi
13 $TExp_{\text{external whole body gamma}}$ = µR/hr * EF * DEP * ED * mrem/µR = mrem

[(2)] dust resuspension pCi/m^3 = pCi/g soil * 0.011mg/m^3 * 1 gr/1000 mg

OU III Ground Water Consumption From the Upper Flow System—Central Tendency Assumptions Long-Term Exposure (continued)

Part 2: Concentrations and Intakes Non Radionuclide and Radionuclide COC's CT Computation

Chemical Name	Exposure Point Concentrations					Chronic Daily Intake—"CT"					Daily Average Intake—"CT"				
	Soils	Sediment	Surface Water	Ground Water	Air	Soils	Sediment	Surface Water	Ground Water	Air	Soils	Sediment	Surface Water	Ground Water	Air
	mg/kg	mg/kg	µg/l	µg/l	mg/m^3	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	mg/kg-day
Arsenic				1.6					3.66E-06					2.8E-05	
Manganese (nonfood)				218					4.99E-04					3.9E-03	
Molybdenum			0	1.7	0	0	0	0	3.89E-06	0	0	0	0	3.0E-05	0
Nitrate				54					1.24E-04					9.6E-04	
Selenium				0.1					2.29E-07					1.8E-06	
Uranium				249					5.70E-04					4.4E-03	
Vanadium				0.3					6.87E-07					5.3E-06	

Radionuclide Name	Exposure Point Concentrations						Period Intake (Exposure)					
	Soils	Sediment	Surface Water	Ground Water	Air	gamma	Soils	Sediment	Surface Water	Ground Water	Air	gamma
	pCi/gr	pCi/gr	pCi/l	pCi/l	pCi/m^3	µR/hr	pCi	pCi	pCi	pCi	pCi	mrem
Uranium-234				71.93859						294588.5261		
Uranium-235+D				3.8097						15600.7215		
Uranium-238+D				83.166						340564.77		
	0			0								

OU III Ground Water Consumption From the Upper Flow System—Central Tendency Assumptions Long-Term Exposure (continued)

Part 3: Risks and HQ's Non Radionuclides, Risks for Radionuclides RME Computation

	Cancer Risk[a]					Non Cancer Hazard Indicies[b]				
	Ingestion		Inhalation		Sum	Ingestion		Inhalation		
Chemical	CDI	Cancer	CDI	Cancer	Cancer	Daily Intake		Daily Intake		Sum
	mg/kg-day	Risk	mg/kg-day	Risk	Risk	mg/kg-day	HI	mg/kg-day	HI	HI
Arsenic	3.7E-06	5.5E-06	0.0E+00	0.0E+00	5.5E-06	2.8E-05	0.1	0.0E+00	0.0E+00	0.1
Manganese (nonfood)	5.0E-04	0.0E+00				3.9E-03	0.2			0.2
Molybdenum	3.9E-06	0.0E+00				3.0E-05	0.0			0.0
Nitrate	1.2E-04	0.0E+00				9.6E-04	0.0			0.0
Selenium	2.3E-07	0.0E+00				1.8E-06	0.0			0.0
Uranium	5.7E-04	0.0E+00				4.4E-03	1.5			1.5
Vanadium	6.9E-07	0.0E+00				5.3E-06	0.0			0.0
0							0.0			0.0
Summation	1.2E-03									
		5.5E-06		0.0E+00	5.5E-06		1.8		0.0E+00	**1.8**

	Ingestion		Inhalation		External		External		External	
Radionuclide Name		Cancer		Cancer	95% UCL	Risk	95% UCL	Risk	95% UCL	Risk
	Total pCi	Risk	Total pCi	Risk	pCi/gr **-Soil**	**Soil**	pCi/gr - **Sediment**	**Sediment**	mrem/period	gamma
Uranium-234	2.9E+05	2.1E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
Uranium-235+D	1.6E+04	1.1E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
Uranium-238+D	3.4E+05	3.0E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		
0		0.0E+00								0.0E+00
								0		
Summation		5.2E-05		0.0E+00		0.0E+00		0.0E+00		

Dose & Dose to Risk Assessment

	Ingestion				External	
Mill tailings	pCi/year	mrem/year	pCi/year	mrem/year	mrem/year	Total
30 year CA Risk =	7.2E+04	2.1E+01	0.0E+00	0.0E+00	0.00	20.51
		1.4E-05		*0.0E+00*	*0.0E+00*	*1.4E-05*

[a]Cancer risk is estimated as follows: CDI × slope factor. The slope factor quantifies toxicity, and it is obtained from the EPA literature (primary source is the Integrated Risk Information System or IRIS). The result is a unitless probability of added cancer risk.
[b]The noncancer hazard index (HI) is the sum of individual hazard quotients (HQ): $HI = HQ_1 + HQ_2 + \ldots HQ_n$. HQ = CDI/Reference dose. Reference dose or RfD is obtained from EPA literature such as IRIS. HI is a unitless, numeric value used to quantify the potential for noncarcinogenic negative health impacts.

Note: Ingestion and inhalation dose evaluations were based on a Monticello mill tailing specific dose conversion factor based on weighted radionuclide content and indexed to Ra-226. Ra-226 has been eliminated as a COPC because of the reduction to nondetectable levels in ground water and the remediation that was complete on the surficial soils. Therefore, new dose conversion factors for ingestion and inhalation were used for the remaining COCs
Dose from external gamma was estimated by the same method as the original risk assessment using measured μR/hr measurements.