0096445

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

11-AMRC-0142

MAY 11 2011

Mr. D. A. Faulk, Program Manager
Office of Environmental Cleanup
Hanford Project Office
U.S. Environmental Protection Agency
309 Bradley Boulevard, Suite 115
Richland, Washington 99352

Dear Mr. Faulk:

TRANSMITTAL OF THE APPROVED WASTE SITE RECLASSIFICATION FORM AND SUPPORTING DOCUMENTATION FOR THE 600-323, BERMED AREA, REVISION 0

Attached for your use is the approved Waste Site Reclassification Form No. 2011-009 and supporting "Remaining Site Verification Package for the 600-323, Bermed Area," Revision 0. If you have questions, please contact me or your staff may contact Jamie Zeisloft, of my staff, at (509) 372-0188.

Sincerely,

D. Chris Smith
for
Mark S. French, Federal Project Director
for the River Corridor Closure Project

AMRC:JHZ

Attachment

cc w/attach:
C. J. Guzzetti, EPA
Administrative Record, H6-08

cc w/o attach:
R. D. Cantwell, WCH
S. L. Feaster, WCH
M. L. Proctor, WCH

RECEIVED
MAY 17 2011
EDMC

100.11.6

Date Submitted: 03/09/11 Originator: M. L. Proctor Phone: 372-9227	**WASTE SITE RECLASSIFICATION FORM** Operable Unit(s): 100-IU-6 Waste Site Code: 600-323 Type of Reclassification Action: Closed Out ☐ Interim Closed Out ☐ No Action ☒ RCRA Postclosure ☐ Rejected ☐ Consolidated ☐	Control Number: 2011-009

This form documents agreement among parties listed authorizing classification of the subject unit as Closed Out, Interim Closed Out, No Action, RCRA Postclosure, Rejected, or Consolidated. This form also authorizes backfill of the waste management unit, if appropriate, for Closed Out and Interim Closed Out units. Final removal from the NPL of No Action and Closed Out waste management units will occur at a future date.

Description of current waste site condition:

The 600-323, Bermed Area waste site consists of a bermed area and underlying soil, as well as coal cinders found at the site. There is a depressed area that runs from east to west on the north side of the waste site. The 600-323 waste site was included in the *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington (EPA 2009) as a candidate site for further evaluation. Confirmatory sampling of this site was performed in November 2010 in accordance with the *Work Instruction for Confirmatory Sampling of the 600-323, Bermed Area*, 0600X-WI-G0043, Rev. 0, Washington Closure Hanford, Richland, Washington (WCH 2010c). The results of confirmatory sampling were used to determine if the waste site meets remedial action objectives and goals established by the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (Remaining Sites ROD), U.S. Environmental Protection Agency, Region 10, Seattle, Washington (EPA 1999). The selected action involved (1) evaluating the site using available process information, (2) demonstrating through confirmatory sampling that cleanup goals have been achieved, and (3) proposing the site for reclassification to No Action.

Basis for reclassification:

In accordance with this evaluation, the confirmatory sampling results support a reclassification of the 600-323 waste site to No Action. The current site conditions achieve the remedial action goals established by the Remaining Sites ROD (EPA 1999). The results of confirmatory sampling show that residual contaminant concentrations do not preclude any future uses (as bounded by the rural-residential scenario) and allow for unrestricted use of shallow-zone soils (i.e., surface to 4.6 m [15 ft] deep). The results also demonstrate that residual contaminant concentrations are protective of groundwater and the Columbia River. Site contamination did not extend into the deep-zone soils. Institutional controls to prevent uncontrolled drilling or excavation into the deep-zone soil are not required. The basis for reclassification is described in detail in the *Remaining Sites Verification Package for the 600-323, Bermed Area* (attached).

Waste Site Controls:

Engineered Controls: Yes ☐ No ☒ Institutional Controls: Yes ☐ No ☒ O&M requirements: Yes ☐ No ☒
If any of the Waste Site Controls are checked Yes specify control requirements including reference to the Record of Decision, TSD Closure Letter, or other relevant documents.

M. S. French DOE Federal Project Director (printed)	M S French Signature	4/18/11 Date
N/A Ecology Project Manager (printed)	Signature	Date
C. Guzzetti EPA Project Manager (printed)	Signature	4/26/11 Date

REMAINING SITES VERIFICATION PACKAGE FOR THE 600-323, BERMED AREA

Attachment to Waste Site Reclassification Form 2011-009

March 2011

REMAINING SITES VERIFICATION PACKAGE FOR THE 600-323, BERMED AREA

EXECUTIVE SUMMARY

The 600-323, Bermed Area waste site consisted of a bermed area and underlying soil, as well as coal cinders found at the site. There is a ditch that runs from east to west on the north side of the waste site. The waste site measures approximately 30 by 30 m (100 by 100 ft) and is depressed approximately 0.5 m (2 ft) relative to the surrounding area.

The 600-323 waste site was included in the *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision, Hanford Site, Benton County, Washington* (EPA 2009) as a candidate site for further evaluation. Confirmatory sampling of the 600-323 waste site was initiated and performed in November 2010 in accordance with the *Work Instruction for Confirmatory Sampling of the 600-323, Bermed Area* (WCH 2010c). The results indicated that the waste site achieved compliance with the remedial action objectives (RAOs) and remedial action goals (RAGs) for the 600-323 waste site, and remediation was not necessary. A summary of the soil results from the confirmatory sampling evaluation compared against the applicable RAGS is presented in Table ES-1. The results of the confirmatory sampling are used to make reclassification decisions for the 600-323 waste site in accordance with the TPA-MP-14 procedure in the *Tri-Party Agreement Handbook Management Procedures* (DOE-RL 2007).

In accordance with this evaluation, the confirmatory sampling results support a reclassification of this site to No Action. The current site conditions achieve the RAOs and the corresponding RAGs established in the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2009) and the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (Remaining Sites ROD) (EPA 1999). These results show that residual soil concentrations support future land uses that can be represented (or bounded) by a rural-residential scenario. The results also demonstrate that residual contaminant concentrations support unrestricted future use of shallow-zone soil (i.e., surface to 4.6 m [15 ft]), and contaminant levels remaining in the soil are protective of groundwater and the Columbia River. The 600-323 waste site contamination did not extend into the deep zone. Institutional controls to prevent uncontrolled drilling or excavation into the deep zone of the site are not required.

Table ES-1. Summary of Remedial Action Goals for the 600-323 Waste site.

Regulatory Requirement	Remedial Action Goals	Results	Remedial Action Objectives Attained?
Direct Exposure – Radionuclides	Attain 15-mrem/yr dose rate above background over 1,000 years.	Radionuclides were not COPCs for this waste site.	NA
Direct Exposure – Nonradionuclides	Attain individual COPC RAGs.	All individual COPC concentrations are below the direct exposure criteria.	Yes
Risk Requirements – Nonradionuclides	Attain a hazard quotient of <1 for all individual noncarcinogens.	All noncarcinogenic COPCs have a hazard quotient of <1.	Yes
	Attain a cumulative hazard quotient of <1 for noncarcinogens.	The cumulative hazard quotient (1.1×10^{-1}) is <1.	
	Attain an excess cancer risk of $<1 \times 10^{-6}$ for individual carcinogens.	The excess cancer risk for all individual COPCs is $<1 \times 10^{-6}$.	
	Attain a cumulative excess cancer risk of $<1 \times 10^{-5}$ for carcinogens.	The cumulative excess cancer risk f (1.9×10^{-7}), is $<1 \times 10^{-5}$.	
Groundwater/River Protection – Radionuclides	Attain single COPC groundwater and river RAGs.	Radionuclides were not COPCs for this waste site.	NA
	Attain National Primary Drinking Water Regulations: 4 mrem/yr (beta/gamma) dose standard to target receptor/organ [a].		
	Meet drinking water standards for alpha emitters: the more stringent of 15 pCi/L MCL or 1/25th of the derived concentration guide for DOE Order 5400.5 [b].		
	Meet total uranium standard of 21.2 pCi/L [c].		
Groundwater/River Protection – Nonradionuclides	Attain individual nonradionuclide groundwater and Columbia River cleanup requirements.	Barium, selenium, benzo(a)pyrene, benzo(b)fluoranthene, and chrysene are present at concentrations above soil RAGs for groundwater and/or Columbia River protection. However, based on RESRAD modeling discussed in Appendix C of the RDR/RAWP (DOE-RL 2009), it is predicted that these constituents will not reach groundwater (and thus the Columbia River) within 1,000 years [d, e].	Yes

[a] "National Primary Drinking Water Regulations" (40 *Code of Federal Regulations* 141).

[b] *Radiation Protection of the Public and Environment* (DOE Order 5400.5).

[c] Based on the isotopic distribution of uranium in the 100 Area, the 30 µg/L MCL corresponds to 21.2 pCi/L. Concentration-to-activity calculations are documented in *Calculation of Total Uranium Activity Corresponding to a Maximum Contaminant Level for Total Uranium of 30 Micrograms per Liter in Groundwater* (BHI 2001).

[d] Based on RESRAD modeling discussed in Appendix C of the RDR/RAWP (DOE-RL 2009), residual concentrations of barium, benzo(a)pyrene, benzo(b)fluoranthene, and chrysene are not expected to migrate more than 3 m (10 ft) vertically in 1,000 years (based on the constituent with the lowest distribution coefficient (K_d value), barium with a K_d of 25 mL/g). The vadose zone underlying the deepest test pit is approximately 12 m (39.4 ft) thick. Therefore, residual concentrations of these constituents are predicted to be protective of groundwater and the Columbia River.

[e] Based on RESRAD modeling discussed in Appendix C of the RDR/RAWP (DOE-RL 2009) and an evaluation of dilution-attenuation in the saturated zone using the formulas from the EPA *Soil Screening Guidance: User's Guide* (EPA 1996), residual soil concentrations of selenium are predicted to be protective of groundwater and the Columbia River for 1,000 years (Appendix B).

COPC = contaminant of potential concern
DOE = U.S. Department of Energy
EPA = U. S. Environmental Protection Agency
MCL = maximum contaminant level
NA = not applicable
RAG = remedial action goal
RDR/RAWP = *Remedial Design Report/Remedial Action Work Plan for the 100 Area*
RESRAD = RESidual RADioactivity

Soil cleanup levels were established in the Remaining Sites ROD (EPA 1999) based in part on a limited ecological risk assessment. Although not required by the Remaining Sites ROD, a comparison against ecological risk screening levels has been made for the site contaminants of potential concern and other constituents. Those constituents exceeding the ecological screening level in the *Washington Administrative Code* Chapter 173-340, Table 749-3 were barium, boron, selenium, and vanadium. U.S. Environmental Protection Agency ecological soil screening levels were also exceeded for barium, manganese, selenium, and vanadium. Exceedance of screening values is intended to trigger additional evaluation and does not necessarily indicate the existence of risk to ecological receptors. Because the maximum detected levels of manganese and vanadium were below Hanford Site background values, it is believed that the presence of these constituents does not pose a risk to ecological receptors. All exceedances will be evaluated in the context of additional lines of evidence for ecological effects as a part of the final closeout decision for the Columbia River corridor portion of the Hanford Site.

REMAINING SITES VERIFICATION PACKAGE FOR THE 600-323, BERMED AREA

STATEMENT OF PROTECTIVENESS

The 600-323, Bermed Area waste site confirmatory sampling data, site evaluations, and supporting documentation demonstrate that this site meets the objectives established in the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP) (DOE-RL 2009) and the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (Remaining Sites ROD) (EPA 1999). These results show that residual soil concentrations support future land uses that can be represented (or bounded) by a rural-residential scenario. The results also demonstrate that residual contaminant concentrations support unrestricted future use of shallow-zone soil (i.e., surface to 4.6 m [15 ft]) and that contaminant levels remaining in the soil are protective of groundwater and the Columbia River. Contamination associated with the 600-323 waste site does not extend into the deep zone. Institutional controls to prevent uncontrolled drilling or excavation into the deep zone of the site are not required.

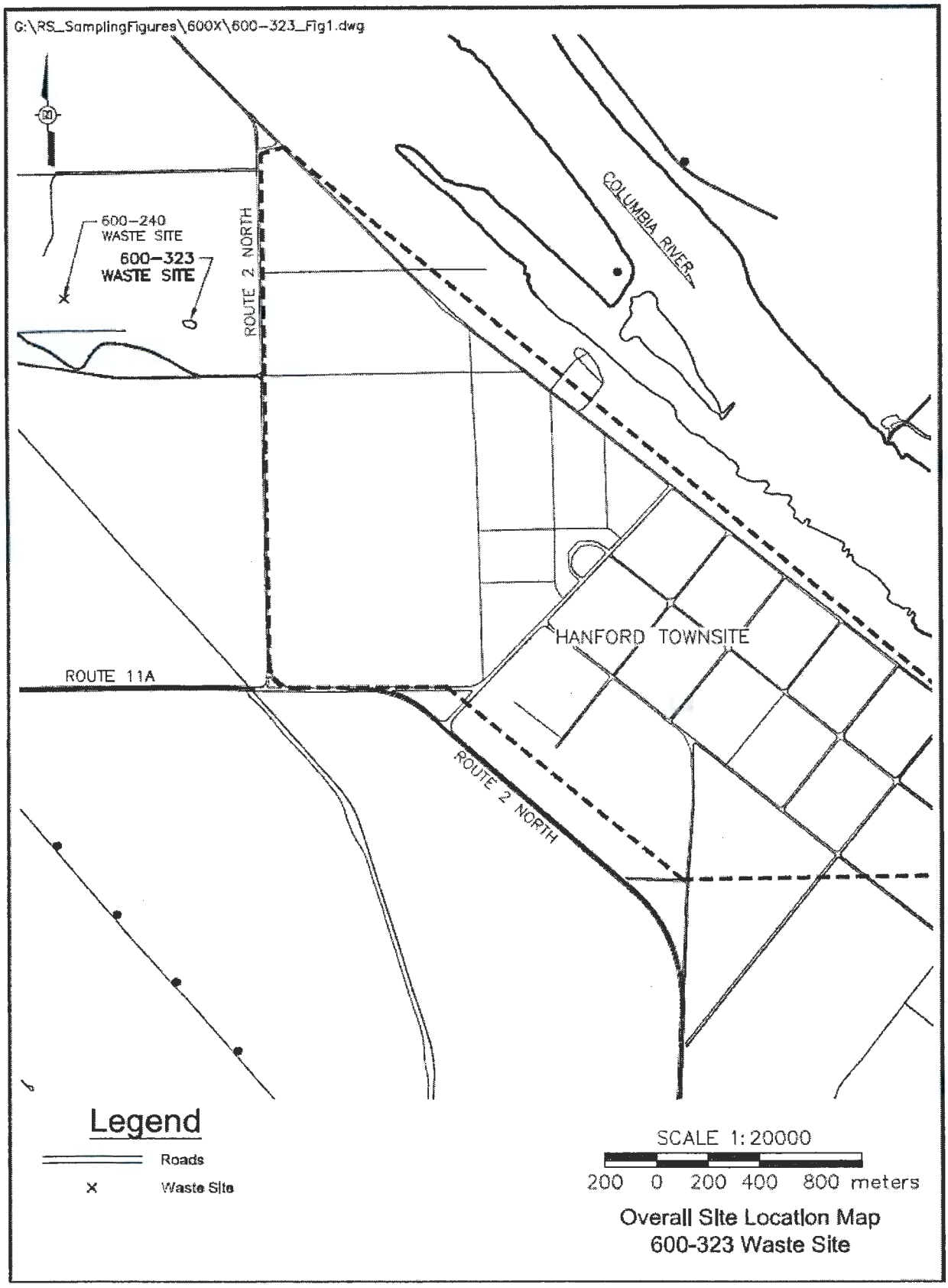
Soil cleanup levels were established in the Remaining Sites ROD (EPA 1999) based in part on a limited ecological risk assessment. Although not required by the Remaining Sites ROD, a comparison against ecological risk screening levels has been made for the site contaminants of potential concern and other constituents. Those constituents exceeding the ecological screening level in the *Washington Administrative Code* Chapter 173-340, Table 749-3 were barium, boron, selenium, and vanadium. U.S. Environmental Protection Agency ecological soil screening levels were also exceeded for barium, manganese, selenium, and vanadium. Exceedance of screening values is intended to trigger additional evaluation and does not necessarily indicate the existence of risk to ecological receptors. Because the maximum detected levels of manganese and vanadium were below Hanford Site background values, it is believed that the presence of these constituents does not pose a risk to ecological receptors. All exceedances will be evaluated in the context of additional lines of evidence for ecological effects as a part of the final closeout decision for the Columbia River corridor portion of the Hanford Site.

GENERAL SITE INFORMATION AND BACKGROUND

The 600-323, Bermed Area waste site consisted of a bermed area and underlying soil, as well as coal cinders found at the site. There is a ditch that runs from east to west on the north side of the waste site. The waste site measures approximately 30 by 30 m (100 by 100 ft) and is depressed approximately 0.5 m (2 ft) relative to the surrounding area. There is no known process history associated with the waste site.

The 600-323 waste site is located approximately 300 m (985 ft) west of Route 2 North and 400 m (1,300 ft) east of the 600-240 waste site (Figure 1). The Washington State Plane coordinates of the 600-323 waste site are N 140263, E 584074.

Figure 1. The 600-323 Waste Site Location Map.



Geophysical Survey

A geophysical survey of the 600-323 waste site was performed in February 2010 to determine if any buried debris was present at the site. No anomalous trends or metallic features were identified in the data. The surface of the bermed areas appears to be fly ash, but no subsurface features were identified in or near the bermed areas (WCH 2010a).

Site Visit

A site visit was performed by the orphan sites evaluation team on April 23, 2007. The bermed areas, an apparent ditch, and an area stained and containing coal cinders were identified.

CONFIRMATORY SAMPLING SUMMARY

The 600-323 waste site was included in the *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision, Hanford Site, Benton County, Washington* (EPA 2009) as a candidate site for further evaluation. Focused samples from five locations, including four test pits and one surface sample, were used to evaluate the 600-323 waste site. Professional judgment, the results of the geophysical survey, and site visit observations were used to identify the location for excavation of the test pits and placement of the surface sample summarized in Table 1. The four test pits were excavated along the two visible bermed areas; two along each bermed area. The surface sample was collected from the area of visible staining.

During excavation of test pit 1, native soil was encountered at approximately 2 m (6 ft) below ground surface (bgs). At test pit 2, native soil was encountered at approximately 2.1 m (7 ft) bgs, and the ash layer was approximately 1.2 m (4 ft) thick. At test pit 3, black ash and coal were encountered to approximately 1 m (3 ft) bgs, and native soil was encountered starting at approximately 2.1 m (7 ft) bgs. At test pit 4, native soil was encountered at approximately 3 m (10 ft) bgs, and the ash layer was 2 m (6 ft) thick. The surface sample consisted of black ash and soil.

Confirmatory sampling indicated that environmental contamination above the remedial action goals (RAGs) was not present at this waste site. Based on confirmatory sampling at the 600-323 waste site, remedial action was determined to be unnecessary, and the confirmatory sampling data has been used for reclassification of this site to No Action. Table 1 and Figure 2 identify the locations and analyses for each confirmatory sample.

Table 1. The 600-323 Waste Site Sample Summary.

Sample	Sample Media	HEIS Number	WSP Coordinate Locations	Invert Depth	Sample Analysis
Test pit 1	Soil from test pit base	J1CMP2	N 140263, E 584068	2 m (6 ft)	ICP metals [a], mercury, PAH, TPH
Test pit 2	Soil from test pit base	J1CMP4	N 140263, E 584081	2.1 m (7 ft)	
Test pit 3	Soil from test pit base	J1CMP1	N 140258, E 584068	2.1 m (7 ft)	
Test pit 4	Soil from test pit base	J1CMP3	N 140257, E 584082	3 m (10 ft)	ICP metals [a], mercury, PAH, TPH
Surface sample 1	Surface soil	J1C2J0	N 140259, E 584090	NA	
Duplicate of surface sample 1	Surface soil	J1C2J1	N 140259, E 584090	NA	
Equipment blank	Silica sand	J1CMP0	NA	NA	ICP metals [a], mercury

[a] Sample evaluation for ICP metals included antimony, arsenic, barium, beryllium, boron, cadmium, chromium (total), cobalt, copper, lead, manganese, molybdenum, nickel, silver, selenium, vanadium, and zinc.

HEIS = Hanford Environmental Information System
ICP = inductively-coupled plasma
NA = not applicable
PAH = polycyclic aromatic hydrocarbons
TPH = total petroleum hydrocarbons
WSP = Washington State Plane

Contaminants of Potential Concern

The contaminants of potential concern (COPCs) for the 600-323 waste site were identified based on professional judgment and field observations. The COPCs included polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPH), lead, and mercury. Although not considered COPCs, analysis was performed for the additional constituents of the expanded inductively coupled plasma (ICP) metals list, including arsenic, antimony, barium, beryllium, boron, cadmium, chromium, cobalt, copper, manganese, molybdenum, nickel, selenium, silver, vanadium, and zinc.

Radiological contamination above background and volatile organic compounds (VOCs) were not detected using field instruments during confirmatory sampling; therefore, analyses for radionuclides and VOCs were not requested. The COPCs for verification sampling and the laboratory analytical methods are identified in Table 2. The results of confirmatory sampling and comparison to the applicable RAGs are presented in Table 3.

Figure 2. 600-323 Confirmatory Sampling Location Map.

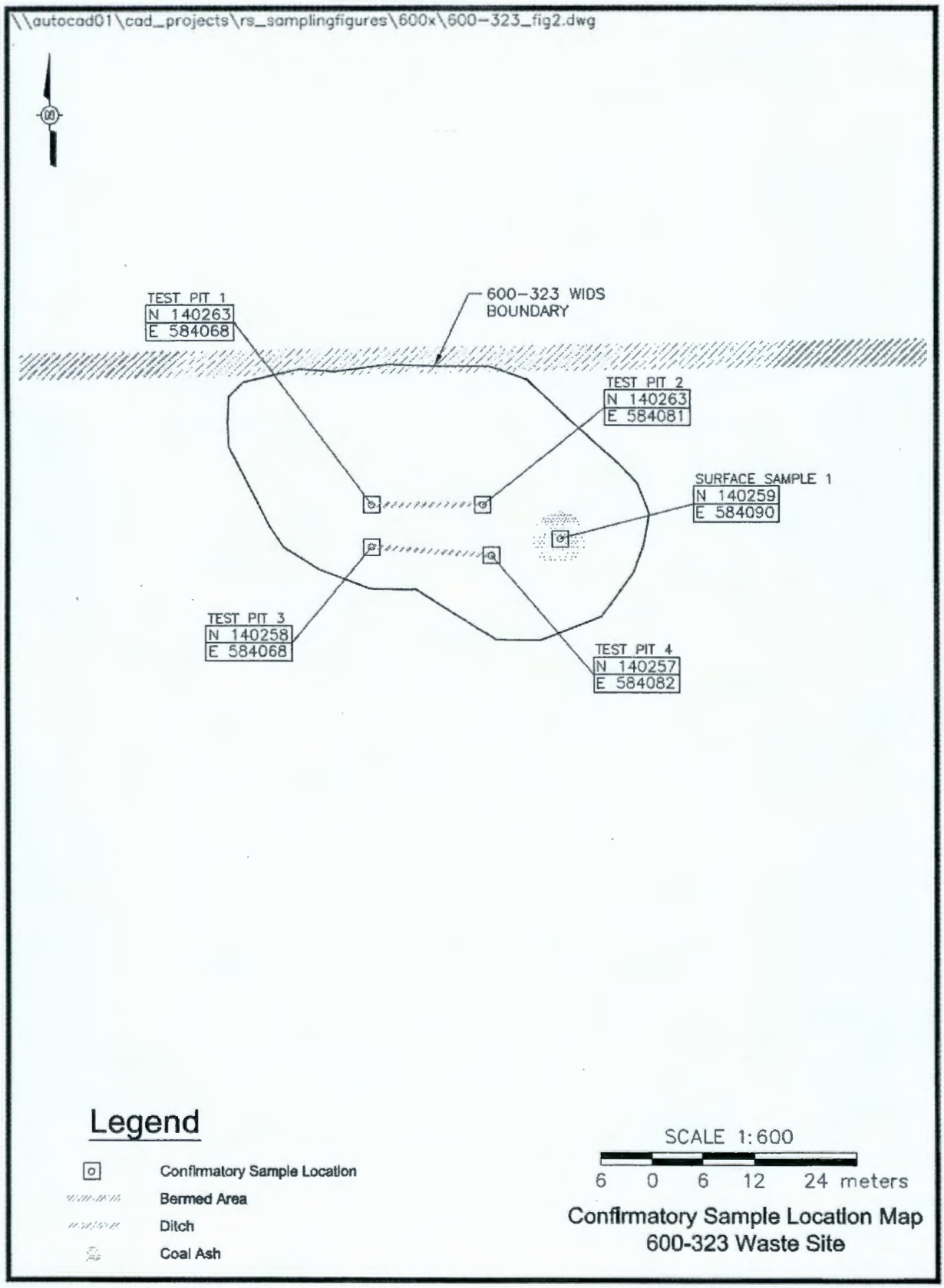


Table 2. Laboratory Analytical Methods.

Analytical Method	Contaminant of Potential Concern
ICP metals – EPA Method 6010	Lead [a]
Mercury – EPA Method 7471	Mercury
PAH – EPA Method 8310	Polycyclic aromatic hydrocarbons
TPH – NWTPH-Dx	Petroleum hydrocarbons

[a] Sample analysis for ICP metals included antimony, arsenic, barium, beryllium, boron, cadmium, chromium (total), cobalt, copper, lead, manganese, molybdenum, nickel, silver, selenium, vanadium, and zinc.

EPA = U.S. Environmental Protection Agency
ICP = inductively coupled plasma
NWTPH-Dx = Northwest total petroleum hydrocarbons
PAH = polycyclic aromatic hydrocarbons
TPH = total petroleum hydrocarbons

Table 3. Comparison of Maximum Contaminant Concentrations to Remedial Action Goals for the 600-323 Waste site Confirmatory Sampling Data. (2 Pages)

COPC	Maximum Result (mg/kg)	Remedial Action Goals [a] (mg/kg)			Does the Maximum Result Exceed RAGs?	Do the Results Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Arsenic	4.3 (<BG)	20 [b]	20 [b]	20 [b]	No	--
Barium	549	5,600	200	400	Yes	Yes [c]
Beryllium	0.68 (<BG)	10.4 [d]	1.51 [b]	1.51 [b]	No	--
Boron [e]	34.0	7,200	320	-- [f]	No	--
Cadmium [g]	0.14 (<BG)	13.9 [d]	0.81 [b]	0.81 [b]	No	--
Chromium (total)	12.6 (<BG)	80,000	18.5 [b]	18.5 [b]	No	--
Cobalt	7.3 (<BG)	24	15.7 [b]	-- [f]	No	--
Copper	20.4 (<BG)	2,960	59.2	22.0 [b]	No	--
Lead	5.2 (<BG)	353	10.2 [b]	10.2 [b]	No	--
Manganese	357 (<BG)	3,760	512 [b]	512 [b]	No	--
Mercury	0.018 (<BG)	24	0.33 [b]	0.33 [b]	No	--
Molybdenum [e]	1.1	400	8	-- [f]	No	--
Nickel	14.1 (<BG)	1,600	19.1 [b]	27.4	No	--
Selenium	2.2	400	5	1	Yes	Yes [h]
Vanadium	37.1 (<BG)	560	85.1 [b]	-- [f]	No	--
Zinc	41.4 (<BG)	24,000	480	67.8 [b]	No	--
TPH – diesel range	50.0	200	200	200	No	--
TPH – motor oil	68.0	200	200	200	No	--
Acenaphthene	0.031	4,800	96	129	No	--
Benzo(a)anthracene	0.0046	1.37	0.015 [i]	0.015 [i]	No	--
Benzo(a)pyrene	0.018	0.137	0.015 [i]	0.015 [i]	Yes	Yes [c]
Benzo(b)fluoranthene	0.050	1.37	0.015 [i]	0.015 [i]	Yes	Yes [c]
Benzo(k)fluoranthene	0.0099	1.37	0.015 [i]	0.015 [i]	No	--
Chrysene	0.170	13.7	0.12	0.1 [i]	Yes	Yes [c]
Fluoranthene	0.087	3,200	64	18.0	No	--

Table 3. Comparison of Maximum Contaminant Concentrations to Remedial Action Goals for the 600-323 Waste site Confirmatory Sampling Data. (2 Pages)

COPC	Maximum Result (mg/kg)	Remedial Action Goals [a] (mg/kg)			Does the Maximum Result Exceed RAGs?	Do the Results Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Napthalene	0.120	1,600	16.0	988	No	--

[a] RAGs obtained from the RDR/RAWP (DOE-RL2009) unless otherwise noted.

[b] Where cleanup levels are less than background, cleanup levels default to background per WAC 173-340-700(4)(d) (Ecology 1996). The arsenic cleanup level of 20 mg/kg has been agreed to by the Tri-Party Agreement Project Managers as discussed in Section 2.1.2.1 of the RDR/RAWP (DOE-RL2009).

[c] Based on RESRAD modeling discussed in Appendix C of the RDR/RAWP (DOE-RL2009), residual concentrations of barium, benzo(a)pyrene, benzo(b)fluoranthene, and chrysene are not expected to migrate more than 3 m (10 ft) vertically in 1,000 years (based on the constituent with the lowest distribution coefficient (K_d value), barium with a K_d of 25 mL/g). The vadose zone underlying the deepest test pit is approximately 12 m (39.4 ft) thick. Therefore, residual concentrations of these constituents are predicted to be protective of groundwater and the Columbia River.

[d] Carcinogenic cleanup level calculated based on the inhalation exposure pathway per WAC 173-340-750(3), (Method B for air quality) and an airborne particulate mass loading rate of 0.0001 g/m^3 (*Hanford Guidance for Radiological Cleanup* [WDOH 1997]).

[e] Hanford Site-specific background value is not available; it was not evaluated during background study. Value used is from *Natural Background Soil Metals Concentrations in Washington State* (Ecology 1994).

[f] No parameters (bioconcentration factors or AWQC values) are available from the Cleanup Levels and Risk Calculations Database (Ecology 2009) or other databases to calculate cleanup levels (WAC 173-340-730(3)(a)(iii), [Method B for surface waters]).

[g] No Hanford Site-specific or Washington State background value available.

[h] Based on RESRAD modeling discussed in Appendix C of the RDR/RAWP (DOE-RL 2009) and the evaluation of dilution-attenuation in the saturated zone using the formulas from the EPA *Soil Screening Guidance: User's Guide* (EPA 1996), residual soil concentrations of selenium are predicted to be protective of groundwater and the Columbia River for 1,000 years (Appendix B).

[i] Where cleanup levels are less than the RDLs, cleanup levels default to the RDLs per WAC 173-340-707(2) (Ecology 1996).

-- = not applicable
AWQC = ambient water quality criteria
BG = background
COPC = contaminant of potential concern
EPA = U. S. Environmental Protection Agency
RAG = remedial action goal
RDL = required detection limit
RDR/RAWP = *Remedial Design Report/Remedial Action Work Plan for the 100 Area*
RESRAD = RESidual RADioactivity (dose model)
TPH = total petroleum hydrocarbons
WAC = *Washington Administrative Code*

Confirmatory Sample Results

Confirmatory samples were analyzed using U.S. Environmental Protection Agency-approved analytical methods. Evaluation of the sample data was performed by direct comparison of the maximum detected value for each COPC against the RAGs.

Comparisons of the maximum results for COPCs and the site RAGs for the 600-323 waste site are presented in Table 3. Contaminants that were not detected by laboratory analysis are excluded from this table. Calculated cleanup levels for aluminum, calcium, iron, magnesium, potassium, silicon, and sodium are not presented in the RDR/RAWP (DOE-RL 2009).

Parameters to calculate cleanup levels for these constituents are not presented in the Cleanup Levels and Risk Calculations (CLARC) Database (Ecology 2009) under WAC 173-340-740(3) or other reference databases; therefore, these constituents are not considered COPCs and are not included in the table. The laboratory-reported data results for all constituents are stored in the Environmental Restoration (ENRE) project-specific database prior to provision to the Hanford Environmental Information System (HEIS) and are presented as an attachment to the direct contact hazard quotient and relative percent difference (RPD) calculation in Appendix A.

DATA EVALUATION

This section demonstrates that contaminant concentrations at the 600-323 waste site achieve the applicable RAGs developed to support unrestricted land use at the 100 Area as established in the Remaining Sites ROD (EPA 1999) and documented in the RDR/RAWP (DOE-RL 2009).

Nonradionuclide Direct Contact Hazard Quotient and Carcinogenic Risk RAGs Attained

Table 3 compares the confirmatory sample values to the applicable soil RAGs for direct exposure, protection of groundwater, and protection of the Columbia River.

Assessment of the risk requirements for the 600-323 waste site was determined by calculation of the hazard quotient and excess carcinogenic risk values for direct contact (Appendix A). Nonradionuclide risk requirements include an individual hazard quotient of less than 1.0, a cumulative hazard quotient of less than 1.0, an individual contaminant carcinogenic risk of less than 1×10^{-6}, and a cumulative carcinogenic risk of less than 1×10^{-5}. For the 600-323 waste site, these risk values were not calculated for constituents that were either not detected or were detected at concentrations below Hanford Site or Washington State background levels. All individual hazard quotients for noncarcinogenic constituents were less than 1.0. The cumulative noncarcinogenic hazard quotient is 1.1×10^{-1}. The cumulative carcinogenic risk value is 1.9×10^{-7}, which is less than the criteria of 1×10^{-6}.

Nonradionuclide Soil RAGS for Groundwater and River Protection Attained

Barium, benzo(a)pyrene, benzo(b)fluoranthene, and chrysene were quantified at concentrations exceeding soil protection RAG for groundwater and river protection. Data were not collected on the vertical extent of these contaminants, but given the soil-partitioning coefficient (K_d) of 25 mL/g for barium, the constituent with the lowest K_d, these constituents are not expected to migrate more than 3 m (10 ft) vertically in 1,000 years (DOE/RL 2009). The vadose zone underlying the base of the deepest test pit is approximately 12 m (39.4 ft) thick; therefore, residual concentrations of these constituents are predicted to be protective of groundwater. The only pathway for contaminant migration to the Columbia River is via groundwater; therefore, residual concentrations of mercury are also predicted to be protective of the Columbia River.

Selenium was quantified at a concentration exceeding soil RAGs for river protection in the surface sample. Selenium was detected just above the river protection RAG (1.0 mg/kg) at 2.2 mg/kg (main) and 1.3 mg/kg (duplicate). The Washington State background value for

selenium is 0.78 mg/kg (Ecology 1994). A careful examination of the selenium data indicates that the maximum concentration is within the range of background (DOE-RL 2001). To further support the case that the selenium detection at 600-323 is protective of the Columbia River, site-specific RESRAD modeling, discussed in Appendix C of the RDR/RAWP (DOE-RL 2009) and the evaluation of dilution-attenuation in the saturated zone using the formulas in the *EPA Soil Screening Guidance: User's Guide* (EPA 1996), were used. Based on this evaluation, residual concentrations of selenium are predicted to be protective of groundwater and the Columbia River for 1,000 years (Appendix B). All other cleanup verification data values are less than the applicable RAGs.

Three-Part Test for Nonradionuclides

A three-part evaluation was performed for focused sampling results. Table 3 presents the maximum value associated with each detected constituent. Maximum results for barium, selenium, benzo(a)pyrene, benzo(b)fluoranthene, and chrysene exceed soil RAGs for groundwater and/or river protection. Because the data set for each focused sample consists of one sample, greater than 10% of the data for these constituents also exceed the same RAG values. Barium and selenium results also exceed more than twice the lowest RAG value (for groundwater and river protection). As discussed previously, soil concentrations of these constituents are predicted to be protective of groundwater and the Columbia River for 1,000 years.

DATA QUALITY ASSESSMENT

A data quality assessment (DQA) was performed to compare the confirmatory sampling approach (WCH 2010c), the field logbook (WCH 2010b), and resulting analytical data with the sampling and data quality requirements specified by the project objectives and performance specifications.

The DQA for the 600-323 waste site established that the data are of the right type, quality, and quantity to support site closeout determination decisions within specified error tolerances. The evaluation verified that the sample design was sufficient for the purpose of clean site confirmation. The confirmatory sample analytical data are stored in the ENRE project-specific database for data evaluation prior to archival in the HEIS and are provided as an attachment to the direct contact hazard quotient RPD calculation in Appendix A. The detailed DQA is presented in Appendix C.

SUMMARY FOR NO ACTION DETERMINATION

The 600-323 waste site has been evaluated in accordance with the Remaining Sites ROD (EPA 1999) and the RDR/RAWP (DOE-RL 2009). Confirmatory sampling was performed, and the analytical results indicate that the residual concentrations of COPCs at this site meet the RAGs and associated RAOs for direct exposure, groundwater protection, and river protection. In

accordance with this evaluation, the verification sampling results support a reclassification of the 600-323 waste site to No Action.

REFERENCES

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

BHI, 2001, *Calculation of Total Uranium Activity Corresponding to a Maximum Contaminant Level for Total Uranium of 30 Micrograms per Liter in Groundwater*, 0100X-CA-V0038, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment,* as amended, U.S. Department of Energy, Washington, D.C.

DOE-RL, 2001, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, DOE/RL-92-24, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2007, *Tri-Party Agreement Handbook Management Procedures,* RL-TPA-90-0001, Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)," Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2009, *Remedial Design Report/Remedial Action Work Plan for the 100 Areas,* DOE/RL-96-17, Rev. 6, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, 1994, *Natural Background Soil Metals Concentrations in Washington State*, Publication No. 94-115, Washington State Department of Ecology, Olympia, Washington.

Ecology, 1996, "Model Toxics Control Act – Cleanup," *Washington Administrative Code* (WAC) 173-340, Washington State Department of Ecology, Olympia, Washington.

Ecology, 2009, Cleanup Levels and Risk Calculations (CLARC) Database, Washington State Department of Ecology, Olympia, Washington, https://fortress.wa.gov/ecy/clarc.CLARCHome.aspx.

EPA, 1996, *Soil Screening Guidance: User's Guide*, OSWER 9355.4-23, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

EPA, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington,* U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

EPA, 2009, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

WAC 173-340, "Model Toxics Control Act—Cleanup," *Washington Administrative Code*, as amended.

WCH, 2010a, *Geophysical Site Investigation Summary, 600-323 Bermed Area,* GI #0602211, Washington Closure Hanford, Richland, Washington.

WCH, 2010b, *Miscellaneous Sampling*, Logbooks EL-1649, pp. 82 and 86, Washington Closure Hanford, Richland, Washington.

WCH, 2010c, *Work Instruction for Confirmatory Sampling of the 600-323, Bermed Area,* 0600X-WI-G0043, Rev. 0, Washington Closure Hanford, Richland, Washington.

WDOH, 1997, *Hanford Guidance for Radiological Cleanup*, WDOH/320-015, Rev. 1, Washington State Department of Health, Olympia, Washington.

APPENDIX A

RELATIVE PERCENT DIFFERENCE (RPD)

AND

DIRECT CONTACT HAZARD QUOTIENT AND CARCINOGENIC RISK CALCULATION

Acrobat 8.0

CALCULATION COVER SHEET

Project Title: IU-2/6 Area Confirmatory Sampling **Job No. 14655**

Area: 100-IU-6

Discipline: Environmental Calculation No: 0600X-CA-V0099 ~~0100H-CA-V0146~~ 3/7/11

Subject: 600-323 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculation

Computer Program: Excel Program No: Excel 2003

The attached calculations have been generated to document compliance with established cleanup levels. These calculations should be used in conjunction with other relevant documents in the administrative record.

Committed Calculation ☒ Preliminary ☐ Superseded ☐ Voided ☐

Rev.	Sheet Numbers	Originator	Checker	Reviewer	Approval	Date
0	Cover = 1 Summary = 7 Attachment 1 = 3 Total = 11	D. I. Rollosson	T. E. Queen	J. D. Skoglie	D. F. Obenauer	3/3/11

SUMMARY OF REVISION

WCH-DE-018 (05/08/2007)

DE01-437.03

Washington Closure Hanford, Inc. CALCULATION SHEET

Originator:	D. I. Rollosson	Date:	1/19/2011	Calc. No.:	0600X-CA-V0099	Rev.:	0
Project:	IU-2/6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	1/19/2011
Subject:	600-323 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations					Sheet No. 1 of 7	

PURPOSE:

Provide documentation to support the calculation of the direct contact hazard quotient (HQ) and excess carcinogenic risk for the 600-323 waste site. In accordance with the remedial action goals (RAGs) in the remedial design report/remedial action work plan (RDR/RAWP) (DOE-RL 2009a), the following criteria must be met:

1) An HQ of <1.0 for all individual noncarcinogens
2) A cumulative HQ of <1.0 for noncarcinogens
3) An excess cancer risk of $<1 \times 10^{-6}$ for individual carcinogens
4) A cumulative excess cancer risk of $<1 \times 10^{-5}$ for carcinogens.

Also, calculate the relative percent difference (RPD) for primary-duplicate sample pairs from 600-323 confirmatory sampling, as necessary.

GIVEN/REFERENCES:

1) DOE-RL, 2009a, *Remedial Design Report/Remedial Action Work Plan for the 100 Area,* DOE/RL-96-17, Rev. 6, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

2) DOE-RL, 2009b, *100 Area Remedial Action Sampling and Analysis Plan,* DOE/RL-96-22, Rev. 5, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

3) EPA, 1994, *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA 540/R-94/013, U.S. Environmental Protection Agency, Washington, D.C.

4) WAC 173-340, "Model Toxics Control Act – Cleanup," *Washington Administrative Code*, 1996.

5) WCH, 2011, *Remaining Sites Verification Package for the 600-323, Bermed Area Waste Site*, Attachment to Waste Site Reclassification Form 2011-009, Washington Closure Hanford, Inc., Richland, Washington.

SOLUTION:

1) Generate an HQ for each noncarcinogenic constituent detected above background or required detection limit/practical quantitation limit and compare it to the individual HQ of <1.0 (DOE-RL 2009a).

2) Sum the HQs and compare this value to the cumulative HQ of <1.0.

3) Generate an excess cancer risk value for each carcinogenic constituent detected above background or required detection limit/practical quantitation limit and compare it to the excess cancer risk of $<1 \times 10^{-6}$ (DOE-RL 2009a).

Washington Closure Hanford, Inc. CALCULATION SHEET

Originator:	D. I. Rollosson	Date:	1/19/2011	Calc. No.:	0600X-CA-V0099	Rev.:	0
Project:	IU-2/6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	1/19/2011
Subject:	600-323 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations					Sheet No. 2 of 7	

4) Sum the excess cancer risk value(s) and compare it to the cumulative cancer risk of $<1 \times 10^{-5}$.

5) Use data from WCH (2011) to perform the RPD calculations for primary-duplicate sample pairs, as required.

METHODOLOGY:

The 600-323 data set is comprised of a single surface sample and four test pit samples at the 600-323 waste site that underwent confirmatory sampling. A duplicate sample was collected from the surface sample location. The direct contact hazard quotient and carcinogenic risk calculations for the 600-323 waste site were conservatively calculated for the entire waste site using the greatest of the maximum soil sample results (WCH 2011). Of the contaminants of potential concern (COPCs) for this site, barium and selenium require HQ and risk calculations because these analytes were detected above background values. Boron, molybdenum, and the detected polycyclic aromatic hydrocarbons require HQ and risk calculations because these analytes were detected and a Washington State or Hanford Site background value is not available. Although total petroleum hydrocarbons (diesel range and motor oil) were detected and no background value is available, the risks associated with total petroleum hydrocarbons do not contribute to the cumulative toxicity calculation. All other site nonradionuclide COPCs were not detected or were quantified below background levels. An example of the HQ and risk calculations is presented below:

1) For example, the maximum value for boron is 34.0 mg/kg, divided by the noncarcinogenic RAG value of 7,200 mg/kg (calculated in accordance with the noncarcinogenic toxics effects formula in WAC 173-340-740[3]), is 4.7×10^{-3}. Comparing this value, and all other individual values, to the requirement of <1.0, this criterion is met.

2) After the HQ calculation is completed for the appropriate analytes, the cumulative HQ can be obtained by summing the individual values. To avoid errors due to intermediate rounding, the individual HQ values prior to rounding are used for this calculation. The sum of the HQ values is 1.1×10^{-1}. Comparing this value to the requirement of <1.0, this criterion is met.

3) To calculate the excess cancer risk, the maximum or statistical value is divided by the carcinogenic RAG value, then multiplied by 1.0×10^{-6}. For example, the maximum value for benzo(a)anthracene is 0.0046 mg/kg, divided by 1.37 mg/kg, and multiplied as indicated, is 3.4×10^{-9}. Comparing this value, and all other individual values, to the requirement of $<1 \times 10^{-6}$, this criterion is met.

4) After these calculations are completed for the carcinogenic analytes, the cumulative excess cancer risk can be obtained by summing the individual values. To avoid errors due to intermediate rounding, the individual cancer risk values prior to rounding are used for this calculation. The sum of the excess cancer risk values is 1.9×10^{-7}. Comparing this value to the requirement of $<1 \times 10^{-5}$, this criterion is met.

5) The RPD is calculated when both the primary value and the duplicate value for a given analyte are above detection limits and are greater than 5 times the target detection limit (TDL). The TDL is a laboratory detection limit pre-determined for each analytical method and is listed for certain analytes in Table II-1 of the SAP (DOE-RL 2009b). Other analytes will have their own pre-determined

Washington Closure Hanford, Inc. CALCULATION SHEET

Originator:	D. I. Rollosson	Date:	1/19/2011	Calc. No.:	0600X-CA-V0099	Rev.:	0
Project:	IU-2/6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	1/19/2011
Subject:	600-323 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations					Sheet No. 3 of 7	

constituents and will have their own TDLs based on the laboratory and method used. Where direct evaluation of the attached sample data showed that a given analyte was not detected in the primary and/or duplicate sample, further evaluation of the RPD value was not performed. The RPD calculations use the following formula:

$$RPD = [\ |M-D|/((M+D)/2)]*100$$

where, M = main sample value D = duplicate sample value

When an analyte is detected in the primary or duplicate sample, but was quantified at less than 5 times the TDL in one or both samples, an additional parameter is evaluated. In this case, if the difference between the primary and duplicate results exceeds a control limit of 2 times the TDL, further assessment regarding the usability of the data is performed. This assessment is provided in the data quality assessment section of the RSVP.

For quality assurance/quality control (QA/QC) duplicate RPD calculations, a value less than 30% indicates the data compare favorably. For regulatory splits, a threshold of 35% is used (EPA 1994). If the RPD is greater than 30% (or 35% for regulatory split data), further investigation regarding the usability of the data is performed. No split samples were collected for cleanup verification of the subject site. Additional discussion is provided in the data quality assessment section of the applicable RSVP (WCH 2011), as necessary.

RESULTS:

1) List individual noncarcinogens and corresponding HQs >1.0: None
2) List the cumulative noncarcinogenic HQ >1.0: None
3) List individual carcinogens and corresponding excess cancer risk >1 x 10^{-6}: None
4) List the cumulative excess cancer risk for carcinogens >1 x 10^{-5}: None

Table 1 shows the results of the hazard quotient and excess cancer risk calculations.

Table 2 shows the results of the RPD calculations for the 600-323 waste site. The evaluation of the QA/QC duplicate RPD calculations is performed within the data quality assessment section of the RSVP.

Washington Closure Hanford, Inc. CALCULATION SHEET

Originator:	D. I. Rollosson	Date:	1/19/2011	Calc. No.:	0600X-CA-V0099	Rev.:	0
Project:	IU-2/6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	1/19/2011
Subject:	600-323 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations					Sheet No. 4 of 7	

Table 1. Direct Contact HQ and Excess Cancer Risk Results for the 600-323 Waste Site.

Contaminants of Potential Concern	Maximum Value[a] (mg/kg)	Noncarcinogen RAG[b] (mg/kg)	Hazard Quotient	Carcinogen RAG[b] (mg/kg)	Carcinogen Risk
Metals					
Barium	549	5,600	9.8E-02	--	--
Boron	34.0	7,200	4.7E-03	--	--
Molybdenum	1.1	400	2.8E-03	--	--
Selenium	2.2	400	5.5E-03	--	--
Inorganics and TPH					
TPH - diesel range and motor oil[c]	118	200	--	--	--
Polyaromatic Hydrocarbons					
Acenaphthene	0.031	4,800	6.5E-06	--	--
Benzo(a)anthracene	0.0046	--	--	1.37	3.4E-09
Benzo(a)pyrene	0.018	--	--	0.137	1.3E-07
Benzo(b)fluoranthene	0.050	--	--	1.37	3.6E-08
Benzo(k)fluoranthene	0.0099	--	--	1.37	7.2E-09
Chrysene	0.17	--	--	13.7	1.2E-08
Fluoranthene	0.087	3,200	2.7E-05	--	--
Naphthalene	0.12	1,600	7.5E-05	--	--
Totals					
Cumulative Hazard Quotient:			**1.1E-01**		
Cumulative Excess Cancer Risk:					**1.9E-07**

Notes:

[a] = From WCH (2011).

[b] = Value obtained from the RDR/RAWP (DOE-RL 2009a) or *Washington Administrative Code* (WAC) 173-340-740(3), Method B, 1996, unless otherwise noted.

[c] = The risks associated with total petroleum hydrocarbons do not contribute to the cumulative toxicity calculation.

-- = not applicable

RAG = remedial action goal

Washington Closure Hanford, Inc. CALCULATION SHEET

Originator:	D. I. Rollosson	Date:	1/19/2011	Calc. No.:	0600X-CA-V0099	Rev.:	0
Project:	IU-2/6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	1/19/2011
Subject:	600-323 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations					Sheet No. 5 of 7	

Table 2. Relative Percent Difference Calculations for the 600-323 Waste Site. (2 Pages)

600-323 Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Aluminum			Arsenic			Barium			Beryllium		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/3/10	13400		1.5	4.3		0.66	549	J	0.076	0.68		0.033
Duplicate of J1C2J0	J1C2J1	11/3/10	12100		1.6	3.8		0.68	418	JM	0.079	0.56		0.034

Analysis:

TDL		5	10	2	0.2
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)	Yes (continue)	Yes (continue)
	Both >5xTDL?	Yes (calc RPD)	No-Stop (acceptable)	Yes (calc RPD)	No-Stop (acceptable)
	RPD	10.2%		27.1%	
	Difference > 2 TDL?	Not applicable	No - acceptable	Not applicable	No - acceptable

Sampling Area	HEIS Number	Sample Date	Boron			Cadmium			Calcium			Chromium		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/3/10	34.0	J	0.98	0.098	B	0.041	17400		14.1	7.0	J	0.058
Duplicate of J1C2J0	J1C2J1	11/3/10	28.4	MJ	1.0	0.14	BM	0.042	13800		14.6	7.1	NJ	0.060

Analysis:

TDL		2	0.2	100	1
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)	Yes (continue)	Yes (continue)
	Both >5xTDL?	Yes (calc RPD)	No-Stop (acceptable)	Yes (calc RPD)	Yes (calc RPD)
	RPD	17.9%		23.1%	1.4%
	Difference > 2 TDL?	Not applicable	No - acceptable	Not applicable	Not applicable

Sampling Area	HEIS Number	Sample Date	Cobalt			Copper			Iron			Lead		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/3/10	3.4		0.10	20.4	L	0.22	8360		3.8	5.2		0.27
Duplicate of J1C2J0	J1C2J1	11/3/10	4.2		0.10	17.2	L	0.22	7990		3.9	5.1		0.28

Analysis:

TDL		2	1	5	5
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)	Yes (continue)	Yes (continue)
	Both >5xTDL?	No-Stop (acceptable)	Yes (calc RPD)	Yes (calc RPD)	No-Stop (acceptable)
	RPD		17.0%	4.5%	
	Difference > 2 TDL?	No - acceptable	Not applicable	Not applicable	No - acceptable

Sampling Area	HEIS Number	Sample Date	Magnesium			Manganese			Mercury			Molybdenum		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/3/10	2530	J	3.7	232		0.10	0.018	BMN	0.0063	1.1	BJ	0.26
Duplicate of J1C2J0	J1C2J1	11/3/10	2690	J	3.8	233		0.10	0.015	B	0.0055	0.70	BM	0.27

Analysis:

TDL		75	5	0.2	2
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)	Yes (continue)	Yes (continue)
	Both >5xTDL?	Yes (calc RPD)	Yes (calc RPD)	No-Stop (acceptable)	No-Stop (acceptable)
	RPD	6.1%	0.4%		
	Difference > 2 TDL?	Not applicable	Not applicable	No - acceptable	No - acceptable

Sampling Area	HEIS Number	Sample Date	Nickel			Potassium			Selenium			Silicon		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/3/10	9.0		0.12	2620		40.9	2.2		0.86	409	LJ	2.1
Duplicate of J1C2J0	J1C2J1	11/3/10	8.4		0.13	2590		42.4	1.3		0.89	216	LMJ	2.2

Analysis:

TDL		4	400	1	2
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)	Yes (continue)	Yes (continue)
	Both >5xTDL?	No-Stop (acceptable)	Yes (calc RPD)	No-Stop (acceptable)	Yes (calc RPD)
	RPD		1.2%		*61.8%*
	Difference > 2 TDL?	No - acceptable	Not applicable	No - acceptable	Not applicable

Note: Gray cells indicate not applicable.

B = estimated result. Result is less than the RL but greater than the MDL.
HEIS = Hanford Environmental Information System
J = estimated result.
L = serial dilution indicates physical and chemical interferences
M = sample precision not met
N = recovery exceeds control limit
PQL = practical quantitation limit.
Q = qualifier
RPD = relative percent difference.
TDL = target detection limit
X = more than 40% difference between columns

Washington Closure Hanford, Inc. CALCULATION SHEET

Originator:	D. I. Rollosson	Date:	1/19/2011	Calc. No.:	0600X-CA-V0099	Rev.:	0
Project:	IU-2/6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	1/19/2011
Subject:	600-323 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations					Sheet No. 6 of 7	

Table 2. Relative Percent Difference Calculations for the 600-323 Waste Site. (2 Pages)

600-323 Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Sodium			Vanadium			Zinc			TPH - diesel range		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	ug/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/3/2010	280		58.8	24.5		0.094	21.8	LJ	0.40	50000		770
Duplicate of J1C2J0	J1C2J1	11/3/2010	239	M	61.0	21.2		0.097	29.0	LMNJ	0.41	44000		710

Analysis:

TDL		50	2.5	1	5000
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)	Yes (continue)	Yes (continue)
	Both >5xTDL?	No-Stop (acceptable)	Yes (calc RPD)	Yes (calc RPD)	Yes (calc RPD)
	RPD		14.4%	28.3%	12.8%
	Difference > 2 TDL?	No - acceptable	Not applicable	Not applicable	Not applicable

Sampling Area	HEIS Number	Sample Date	TPH - motor oil			Benzo(a)pyrene			Benzo(b)fluoranthene			Benzo(k)fluoranthene		
			ug/kg	Q	PQL	ug/kg	Q	PQL	ug/kg	Q	PQL	ug/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/3/2010	68000		1100	7.2	U	7.2	43	X	4.7	5.9	JNX	4.4
Duplicate of J1C2J0	J1C2J1	11/3/2010	62000	N	1000	6.7	U	6.7	50		4.4	9.8	JX	4.1

Analysis:

TDL		5000	15	15	15
Duplicate Analysis	Both > PQL?	Yes (continue)	No-Stop (acceptable)	Yes (continue)	Yes (continue)
	Both >5xTDL?	Yes (calc RPD)		No-Stop (acceptable)	No-Stop (acceptable)
	RPD	9.2%			
	Difference > 2 TDL?	Not applicable	No - acceptable	No - acceptable	No - acceptable

Sampling Area	HEIS Number	Sample Date	Chrysene			Naphthalene		
			ug/kg	Q	PQL	ug/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/3/2010	120		5.5	110		14
Duplicate of J1C2J0	J1C2J1	11/3/2010	170		5.1	120		13

Analysis:

TDL		15	15
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)
	Both >5xTDL?	Yes (calc RPD)	Yes (calc RPD)
	RPD	*34.5%*	8.7%
	Difference > 2 TDL?	Not applicable	Not applicable

Washington Closure Hanford, Inc. CALCULATION SHEET

Originator:	D. I. Rollosson	Date:	1/19/2011	Calc. No.:	0600X-CA-V0099	Rev.:	0
Project:	IU-2/6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	1/19/2011
Subject:	600-323 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations					Sheet No. 7 of 7	

CONCLUSION:

The calculations in Tables 1 and 2 demonstrate that the 600-323 waste site meets the requirements for the hazard quotients and carcinogenic (excess cancer) risk and RPDs, respectively, as identified in the RDR/RAWP (DOE-RL 2009a) and SAP (DOE-RL 2009b). The hazard quotients and carcinogenic (excess cancer) risk and RPD calculations are for use in the RSVP for this site.

Attachment 1. 600-323 Confirmatory Sampling Results (Metals).

Sample Location	HEIS Number	Sample Date	Aluminum			Antimony			Arsenic			Barium			Beryllium		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/03/10	13400		1.5	0.38	UJ	0.38	4.3		0.66	549	J	0.076	0.68		0.033
Duplicate of J1C2J0	J1C2J1	11/03/10	12100		1.6	0.39	UJ	0.39	3.8		0.68	418	JM	0.079	0.56		0.034
600-323 TP3	J1CMP1	11/02/10	6870		1.5	0.36	U	0.36	2.5		0.63	71.0	J	0.073	0.16	B	0.032
600-323 TP1	J1CMP2	11/03/10	9160	L	1.6	0.40	U	0.40	3.6		0.70	199	JL	0.080	0.32		0.035
600-323 TP4	J1CMP3	11/03/10	5590	L	1.6	0.39	U	0.39	2.0	N	0.68	75.5	M	0.078	0.17	BN	0.034
600-323 TP2	J1CMP4	11/03/10	9770	L	1.8	0.45	U	0.45	3.6		0.78	96.4	JL	0.090	0.23	B	0.039
Equipment Blank	J1CMP0	11/02/10	160		1.5	0.37	U	0.37	0.64	U	0.64	2.0	J	0.074	0.032	U	0.032

Sample Location	HEIS Number	Sample Date	Boron			Cadmium			Calcium			Chromium			Cobalt		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/03/10	34.0	J	0.98	0.098	B	0.041	17400		14.1	7.0	J	0.058	3.4		0.10
Duplicate of J1C2J0	J1C2J1	11/03/10	28.4	MJ	1.0	0.14	BM	0.042	13800		14.6	7.1	NJ	0.060	4.2		0.10
600-323 TP3	J1CMP1	11/02/10	3.1		0.94	0.076	BM	0.039	4560	J	13.5	10.5		0.055	5.9	L	0.096
600-323 TP1	J1CMP2	11/03/10	24.6		1.0	0.093	B	0.043	9150	JL	14.9	10.5	L	0.061	6.5		0.11
600-323 TP4	J1CMP3	11/03/10	7.0	MN	1.0	0.094	B	0.042	4580	JLM	14.5	7.7	LN	0.060	4.6	N	0.10
600-323 TP2	J1CMP4	11/03/10	6.8		1.2	0.079	B	0.048	9160	JL	16.6	12.6	L	0.068	7.3		0.12
Equipment Blank	J1CMP0	11/02/10	0.95	U	0.95	0.040	U	0.040	39.0	BJC	13.7	0.11	B	0.056	0.097	UL	0.097

Sample Location	HEIS Number	Sample Date	Copper			Iron			Lead			Magnesium			Manganese		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/03/10	20.4	L	0.22	8360		3.8	5.2		0.27	2530	J	3.7	232		0.10
Duplicate of J1C2J0	J1C2J1	11/03/10	17.2	L	0.22	7990		3.9	5.1		0.28	2690	J	3.8	233		0.10
600-323 TP3	J1CMP1	11/02/10	14.1		0.21	16600		3.6	3.3		0.26	4500		3.5	296		0.096
600-323 TP1	J1CMP2	11/03/10	16.5	L	0.23	16200	L	4.0	4.7		0.29	4950	JL	3.9	314	L	0.11
600-323 TP4	J1CMP3	11/03/10	11.5	L	0.22	11800	L	3.9	3.3		0.28	3670	JL	3.8	225	L	0.10
600-323 TP2	J1CMP4	11/03/10	19.5	L	0.26	19700	L	4.5	4.6		0.32	6260	JL	4.4	357	L	0.12
Equipment Blank	J1CMP0	11/02/10	0.21	U	0.21	239		3.7	0.44	B	0.26	21.0		3.6	4.7		0.097

Sample Location	HEIS Number	Sample Date	Mercury			Molybdenum			Nickel			Potassium			Selenium		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/03/10	0.018	BMN	0.0063	1.1	BJ	0.26	9.0		0.12	2620		40.9	2.2		0.86
Duplicate of J1C2J0	J1C2J1	11/03/10	0.015	B	0.0055	0.70	BMNJ	0.27	8.4		0.13	2590		42.4	1.3		0.89
600-323 TP3	J1CMP1	11/02/10	0.0055	U	0.0055	0.25	U	0.25	11.2		0.12	981		39.2	0.82	U	0.82
600-323 TP1	J1CMP2	11/03/10	0.0065	U	0.0065	0.41	B	0.27	11.6	L	0.13	1400		43.3	0.91	U	0.91
600-323 TP4	J1CMP3	11/03/10	0.011	B	0.0062	0.27	UN	0.27	8.5	LN	0.13	761		42.2	0.88	UN	0.88
600-323 TP2	J1CMP4	11/03/10	0.0063	U	0.0063	0.31	U	0.31	14.1	L	0.14	1430		48.3	1.0	U	1.0
Equipment Blank	J1CMP0	11/02/10	0.0055	U	0.0055	0.28	B	0.25	0.12	B	0.12	55.8	B	39.8	0.83	U	0.83

Acronyms and notes apply to all of the tables in this attachment.

Gray cells indicate not applicable.

Note: Data qualified with B, C, and/or J are considered acceptable values.

B = blank contamination (organic constituents) = Estimated (inorganic)
C = analyted detected in both sample and associated blank
HEIS=Hanford Environmental Information System
J = estimated
L = serial dilution indicates physical and chemical interferences
M = sample precision not met
N = recovery exceeds control limit
PQL = practical quantitation limit
Q = qualifier
U = undetected
X = more than 40% difference between columns

Attachment	1	Sheet No.	1 of 3
Originator	D. I. Rollosson	Date	1/18/11
Checked	T. E. Queen	Date	1/18/11
Calc. No.	0600X-CA-V0099	Rev. No.	0

Attachment 1. 600-323 Confirmatory Sampling Results (Metals).

Sample Location	HEIS Number	Sample Date	Silicon			Silver			Sodium			Vanadium			Zinc		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/03/10	409	LJ	2.1	0.16	U	0.16	280	J	58.8	24.5		0.094	21.8	LJ	0.40
Duplicate of J1C2J0	J1C2J1	11/03/10	216	LMJ	2.2	0.17	UN	0.17	239	MJ	61.0	21.2		0.097	29.0	LMNJ	0.41
600-323 TP3	J1CMP1	11/02/10	238		2.1	0.15	U	0.15	236		56.4	37.1		0.090	33.5		0.38
600-323 TP1	J1CMP2	11/03/10	974	L	2.2	0.17	U	0.17	331		62.3	36.5	L	0.099	33.8	L	0.42
600-323 TP4	J1CMP3	11/03/10	143	LM	2.2	0.16	U	0.16	214		60.7	27.7	L	0.097	21.0	LN	0.41
600-323 TP2	J1CMP4	11/03/10	1340	L	2.5	0.19	U	0.19	267		69.5	44.0	L	0.11	41.4	L	0.47
Equipment Blank	J1CMP0	11/02/10	118		1.9	0.16	U	0.16	57.3	U	57.3	0.21	B	0.091	1.1		0.39

Sample Location	HEIS Number	Sample Date	TPH - diesel range			TPH - motor oil		
			ug/kg	Q	PQL	ug/kg	Q	PQL
600-323 Surface Sample	J1C2J0	11/03/10	50000		770	68000		1100
Duplicate of J1C2J0	J1C2J1	11/03/10	44000		710	62000	N	1000
600-323 TP3	J1CMP1	11/02/10	2600	J	680	3500	J	990
600-323 TP1	J1CMP2	11/03/10	6100		770	16000		1100
600-323 TP4	J1CMP3	11/03/10	2000	J	800	3100	J	1200
600-323 TP2	J1CMP4	11/03/10	1600	J	790	1900	J	1200
Equipment Blank	J1CMP0	11/02/10						

Attachment	1	Sheet No.	2 of 3
Originator	D. I. Rollosson	Date	1/19/11
Checked	T. E. Queen	Date	1/19/11
Calc. No.	0600X-CA-V0099	Rev. No.	0

Attachment 1. 600-323 Confirmatory Sampling Results (Organics).

HEIS Number	J1C2J0			J1C2J1			J1C2MP1			J1CMP2			J1CMP3			J1CMP4		
Sample Date	11/3/2010			11/3/2010			11/2/2010			11/3/2010			11/3/2010			11/3/2010		
Sample Location	Surface Sample			Duplicate of J1C2J0			TP3			TP1			TP4			TP2		
CONSTITUENT	µg/kg	Q	PQL	µg/kg	Q	PQL	µg/kg	Q	PQL	µg/kg	Q	PQL	µg/kg	Q	PQL	µg/kg	Q	PQL
Polycyclic Aromatic Hydrocarbons (PAH)																		
Acenaphthene	11	U	11	31	J	10	10	U	10	12	U	12	12	U	12	12	U	12
Acenaphthylene	10	U	10	9.4	U	9.4	9.1	U	9.1	11	U	11	11	U	11	10	U	10
Anthracene	3.4	U	3.4	3.2	U	3.2	3.1	U	3.1	3.6	U	3.6	3.6	U	3.6	3.5	U	3.5
Benzo(a)anthracene	4.6	J	3.6	3.3	U	3.3	3.2	U	3.2	3.8	U	3.8	3.8	U	3.8	3.7	U	3.7
Benzo(a)pyrene	7.2	U	7.2	6.7	U	6.7	6.5	U	6.5	7.6	U	7.6	7.5	U	7.5	18		7.4
Benzo(b)fluoranthene	43	X	4.7	50		4.4	4.2	U	4.2	8.1	J	5.0	4.9	U	4.9	4.8	U	4.8
Benzo(ghi)perylene	8.1	U	8.1	7.5	U	7.5	7.3	U	7.3	8.5	U	8.5	8.5	U	8.5	8.3	U	8.3
Benzo(k)fluoranthene	5.9	JNX	4.4	9.8	JX	4.1	4	U	4	9.9	J	4.7	4.6	U	4.6	4.5	U	4.5
Chrysene	120		5.5	170		5.1	4.9	U	4.9	62		5.7	8.4	J	5.7	5.6	U	5.6
Dibenz[a,h]anthracene	12	UN	12	11	U	11	11	U	11	13	U	13	13	U	13	13	U	13
Fluoranthene	15	U	15	87	X	14	13	U	13	15	U	15	15	U	15	15	U	15
Fluorene	6.0	U	6.0	5.5	U	5.5	5.3	U	5.3	6.3	U	6.3	6.2	U	6.2	6.1	U	6.1
Indeno(1,2,3-cd)pyrene	14	UN	14	13	U	13	12	U	12	14	U	14	14	U	14	14	U	14
Naphthalene	110		14	120		13	12	U	12	14	U	14	14	U	14	14	U	14
Phenanthrene	14	U	14	13	U	13	12	U	12	14	U	14	14	U	14	14	U	14
Pyrene	14	U	14	13	U	13	12	U	12	14	U	14	14	U	14	14	U	14

Attachment	1	Sheet No.	3 of 3
Originator	D. I. Rollosson	Date	1/18/11
Checked	T. E. Queen	Date	1/18/11
Calc. No.	0600X-CA-V0099	Rev. No.	0

APPENDIX B

RESRAD CALCULATION

CALCULATION COVER SHEET

Project Title: 100-IU-2/6 Field Remediation **Job No. 14655**

Area: 100-IU-6

Discipline: Environmental *Calculation No: 0600X-CA-V0107

Subject: 600-323 RESRAD Calculation Brief for Groundwater and River Protection

Computer Program: RESRAD Program No: Version 6.5

The attached calculations have been generated to document compliance with established cleanup levels. These calculations should be used in conjunction with other relevant documents in the administrative record.

Committed Calculation ☒ Preliminary ☐ Superseded ☐ Voided ☐

Rev.	Sheet Numbers	Originator	Checker	Reviewer	Approval	Date
0	Cover – 1 pg Summary – 5 pg Attm. 1 - 19 pg Attm. 2 - 9 pg Total – 34 pages	S. W. Clark	M. W. Perrott	T. E. Queen	D. F. Obenauer	2/22/11

SUMMARY OF REVISION

WCH-DE-018 (05/08/2007) *Obtain Calc. No. from Document Control and Form from Intranet

Washington Closure Hanford CALCULATION SHEET

Originator:	S. W. Clark	Date:	2/17/11	Calc. No.:	0600X-CA-V0107	Rev.:	0
Project:	100-IU-2/6 Field Remediation	Job No:	14655	Checked:	M. W. Perrott	Date:	2/17/11
Subject:	600-323 RESRAD Calculation Brief for Groundwater and River Protection					Sheet No. 1 of 5	

PURPOSE:

Predict the groundwater and Columbia River concentrations over a period of 1,000 years from selenium analyses of the soil at the 600-323 confirmatory sampling site.

GIVEN/REFERENCES:

1) A focused surface sample and duplicate were collected from an area of visible staining at the 600-323 waste site (HEIS # J1C2J0 & J1C2J1). Selenium analyses of both samples exceeded the soil cleanup level for protection of the Columbia River of 1 mg/kg. The maximum of the two selenium analyses of 2.2 mg/kg was evaluated by site-specific RESidual RADioactivity (RESRAD) modeling for nonradionuclides as described in Appendix C of the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP). The focused samples represent an area of 900 m^2 (9,690 ft^2). A site-specific RESRAD evaluation was performed to predict the selenium concentrations in groundwater. Dilution and attenuation of selenium concentrations in groundwater as it flows from the area of the 600-323 waste site to the Columbia River was calculated using the U.S. Environmental Protection Agency (EPA) *Soil Screening Guidance: User's Guide.*
2) Selenium analyses from the focused sampling area (HEIS # J1C2J0 & J1C2J1) were obtained from the *600-323 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations UCL Calculations*, Calc. No. 0600X-CA-V0099, Rev. 0, Washington Closure Hanford, Richland, Washington.
3) *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP), DOE/RL-96-17, Rev. 6, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
3) RESidual RADioactivity (RESRAD) computer code, version 6.5, to calculate compliance with residual radioactivity guidelines, developed for the U.S. Department of Energy by the Environmental Assessment Division of Argonne National Laboratory, Argonne, Illinois.
4) Formulas for calculation of dilution and attenuation in groundwater between the waste site and the Columbia River were obtained from the *Soil Screening Guidance: User's Guide*, OSWER 9355.4-23, July 1996, U.S. Environmental Protection Agency, Washington, D.C.
5) Sample design from the *Work Instruction for Confirmatory Sampling of the 600-323, Bermed Area*, Work Instruction No. 0600X-WI-G0043, Rev. 0, Washington Closure Hanford, Richland, Washington.

SOLUTION:

1) As discussed in Section 3.6.9 of the RDR/RAWP, the residual concentrations of nonradionuclides in the soil are compared to the soil remedial action goals (RAGs) for Columbia River protection developed in Table B-6 of Appendix B of the RDR/RAWP. The river protection RAG is attained if the residual concentrations in soil are less than the Table B-6 RAGs and each sample data set meets the requirements of the WAC 173-340-740(7)(e) (1996) three-part test. If this is not the case, a more detailed assessment using RESRAD or other appropriate methods (e.g., dilution-attenuation evaluations) is used to assess the potential of residual site soil contaminants to impact groundwater and the river. If

this assessment indicates that the residual contamination in the site soils will not impact groundwater or the river at concentrations above groundwater or surface water cleanup levels, then the groundwater and river protection RAGs have been attained.

2) A site-specific RESRAD evaluation was performed for the maximum selenium concentration at the 600-323 waste site focused sample location in an area of visible staining (HEIS # J1C2J0 & J1C2J1). The area of influence of the samples for purposes of the RESRAD evaluation is 900 m^2 (9,690 ft^2). Table 1 shows the waste site area dimensions and thickness of each soil horizon used in the RESRAD and dilution-attenuation calculations. Input factors for each run are shown in the "Summary" section of the RESRAD "Mixture Sums and Single Radionuclide Guidelines" printout in Attachment 1 to this Calculation Summary.

Table 1. Waste Site-Specific Parameters for RESRAD and Dilution-Attenuation Modeling

Parameter	Units	Shallow Zone
Contaminant-Specific Input Parameters		
Selenium Maximum Concentration	mg/kg	2.2
Selenium Kd Value	mL/g	5
Contaminated Zone Dimensions		
Cover Depth	m	0
Area of Contaminated Zone (CZ)	m^2	900
Length Parallel to Aquifer Flow	m	30
Thickness of Vadose Zone Horizons		
Thickness: Contaminated Zone	m	1.0
Thickness: Unsaturated Zone	m	12.0
Distance from the Waste Site to the Columbia River		
Saturated Zone Groundwater Flow Distance	m	1,025

3) The year when the peak selenium concentration is predicted to occur in groundwater from the waste site was determined by a preliminary run. This year was then added for all horizons for the final RESRAD runs. For the water pathways, the peak year for selenium in groundwater is predicted to occur at year 487.

METHODOLOGY:

1) Using the methodology described in Appendix C of the RDR/RAWP, RESRAD modeling was used to determine if residual soil concentrations of selenium are protective of groundwater. Runs of RESRAD version 6.5 were completed for the maximum selenium concentration in the 600-323 waste site confirmatory focused sampling activities using the uranium-238 isotope as a surrogate for selenium. RESRAD numerical output reports of selenium concentrations in soil and groundwater are presented in the Attachments to this calculation summary.

Washington Closure Hanford CALCULATION SHEET

Originator:	S. W. Clark	Date:	2/17/11	Calc. No.:	0600X-CA-V0107	Rev.:	0
Project:	100-IU-2/6 Field Remediation	Job No:	14655	Checked:	M. W. Perrott	Date:	2/17/11
Subject:	600-323 RESRAD Calculation Brief for Groundwater and River Protection					Sheet No. 3 of 5	

2) Methodology for modeling to protect the Columbia River is similar to that for modeling the protection of groundwater, with the groundwater concentration reduced by using a factor to account for dilution and attenuation as contaminants migrate through the groundwater to the river. Calculation of an appropriate dilution factor is accomplished using the formulas in the EPA *Soil Screening Guidance: User's Guide.*

The following Excel spreadsheet incorporates the formulas for calculation of the dilution factor to account for dilution and attenuation as contaminants migrate through the groundwater to the river:

Table 2. Excel Calculation of Dilution Factor for Protection of the Columbia River

	A	B	C	D	E	F	G	H
1	Apparent Mixing Zone Depth (d) is calculated per the EPA *Soil Screening Guidance: User's Guide User's*, Equation 12:							
2	Apparent Mixing Zone Depth (d) = $(0.0112*L^2)^{0.5} + d_a(1 - \exp((-L*I)/(K*i*d_a)))$							
3	Variable	Value	Description					
4	L	1025	m, Distance to the Columbia River					
5	d_a	10	m, Aquifer Thickness					
6	I	0.07992	m/yr, Infiltration Rate, from I = (1-Ce((1-Cr)Pr + Irr					
7	Ce	0.91	Evapotranspiration Coefficient					
8	Cr	0.2	Runoff Coefficient					
9	Pr	0.16	m/yr, Precipitation					
10	Irr	0.76	m/yr, Irrigation					
11	K	5530	m/yr, Aquifer Hydraulic Conductivity					
12	i	0.00125	m/m, Hydraulic Gradient					
13								
14	Calculation of Dilution Factor per the EPA *Soil Screening Guidance: User's Guide User's*, Equation 11.							
15	Dilution Factor, D = 1 + (K*i*d/I*L)							
16	Variable	Value	Description					
17	K	5530	m/yr, Aquifer Hydraulic Conductivity					
18	i	0.00125	m/m, Hydraulic Gradient					
19	d	115.4	m, Apparent Mixing Zone Depth (see formula below)					
20	I	0.07992	m/yr, Infiltration Rate, from I = (1-Ce((1-Cr)Pr + Irr					
21	L	1025	m, Distance to the Columbia River					
22								
23	Apparent Mixing Zone Depth (d) = E26 = ((0.0112*B4*B4)^0.5)+(B5*(1-EXP((-B4)*(B6)/(B11*B12*B5)))							
24	Dilution Factor (D) = E27 = 1+((B17*B18*B19)/(B20*B21))							
25								
26				Apparent Mixing Zone Depth (d) =	115.4	m		
27				Dilution Factor (D) =	10.7			

RESULTS:

1) Groundwater Protection

The selenium concentrations in groundwater at different time intervals for 1,000 years were calculated by the RESRAD model using uranium-238 as a radionuclide surrogate for selenium. RESRAD output is presented in Attachment 2 and summarized in Table 3. Selenium is predicted

Washington Closure Hanford CALCULATION SHEET

Originator:	S. W. Clark	Date:	2/17/11	Calc. No.:	0600X-CA-V0107	Rev.:	0
Project:	100-IU-2/6 Field Remediation	Job No:	14655	Checked:	M. W. Perrott	Date:	2/17/11
Subject:	600-323 RESRAD Calculation Brief for Groundwater and River Protection					Sheet No. 4 of 5	

to reach groundwater within the 1,000 years of the RESRAD model evaluation and is predicted to peak at year 487 at a maximum groundwater concentration of 28.7 ug/L, which is less than the groundwater remedial action goal (RAG) of 50 ug/L per Table B-2 of Appendix B of the RDR/RAWP.

Table 3. Predicted Groundwater (Well Water/Drinking Water) Concentration at 600-323

Contaminant	RESRAD Run	Groundwater Concentrations in ug/L at Each Time Interval (yr)								RAG, ug/L
		0	1	3	10	30	100	487	1000	
Selenium	600-323	0	0	0	0	0	0	28.7	0.17	50[a]

[a] Based on the maximum contaminant level (MCL) for selenium from 40 CFR 141, as discussed in Appendix B, Table B-2, of the 100 Area RDR/RAWP.

2) Columbia River Protection

Predicted selenium concentrations in groundwater at the Columbia River were calculated by dividing the predicted groundwater concentrations at the 600-323 waste site in Table 3 by the dilution factor of 10.7 determined in Table 2. Results are summarized in Table 4. Due to dilution and attenuation, selenium is predicted to reach the river at a maximum groundwater concentration of 2.7 ug/L, which is less than the remedial action goal (RAG) of 5.0 ug/L per Table B-3 of Appendix B of the RDR/RAWP.

Table 4. Predicted Groundwater Concentration at the Columbia River Based on Dilution and Attenuation of Groundwater from 600-323

Contaminant	RESRAD Run	Groundwater Concentrations in ug/L at Each Time Interval (yr)								RAG, ug/L
		0	1	3	10	30	100	487	1000	
Selenium	600-323	0	0	0	0	0	0	2.7	0.016	5.0[a]

[a] Based on the surface water ambient water quality criteria (AWQC) for selenium from 40 CFR 131.36, as discussed in Appendix B, Table B-3, of the 100 Area RDR/RAWP.

CONCLUSIONS:

- Maximum selenium concentrations in the soil at the 600-323 waste site are predicted to be protective of groundwater and the Columbia River for 1,000 years based upon RESRAD vadose zone modeling and evaluation of dilution-attenuation in the saturated zone using the formulas in the EPA *Soil Screening Guidance: User's Guide.*

- The selenium concentrations in groundwater at different time intervals to 1,000 years as calculated by the RESRAD model using uranium-238 as a surrogate are summarized in Table 3. Selenium concentrations in groundwater are predicted to peak at year 487 at a maximum concentration of 28.7 ug/L, which is less than the groundwater cleanup RAG of 50 ug/L per Table B-2 of Appendix B of the RDR/RAWP.

Washington Closure Hanford CALCULATION SHEET

Originator:	S. W. Clark	Date:	2/17/11	Calc. No.:	0600X-CA-V0107	Rev.:	0
Project:	100-IU-2/6 Field Remediation	Job No:	14655	Checked:	M. W. Perrott	Date:	2/17/11
Subject:	600-323 RESRAD Calculation Brief for Groundwater and River Protection					Sheet No. 5 of 5	

- Selenium concentrations in groundwater at the Columbia River were calculated by dividing the predicted groundwater concentrations at the 600-323 waste site in Table 3 by the dilution factor determined in Table 2. Results are summarized in Table 4. Due to dilution and attenuation, selenium is predicted to reach the river at a maximum concentration of 2.7 ug/L, which is less than the surface water cleanup RAG of 5.0 ug/L per Table B-3 of Appendix B of the RDR/RAWP.

ATTACHMENTS:

1. RESRAD Output: 600-323 Selenium Groundwater and River Protection – Mixture Sums and Single Radionuclide Guidelines (19 pages)
2. RESRAD Output: 600-323 323 Selenium Groundwater and River Protection – Concentration of Radionuclides, (9 pages)

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  07:12  Page   1
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary ... 2
Site-Specific Parameter Summary 4
Summary of Pathway Selections 8
Contaminated Zone and Total Dose Summary 9
Total Dose Components
Time = 0.000E+00 10
Time = 1.000E+00 11
Time = 3.000E+00 12
Time = 1.000E+01 13
Time = 3.000E+01 14
Time = 1.000E+02 15
Time = 4.870E+02 16
Time = 1.000E+03 17
Dose/Source Ratios Summed Over All Pathways 18
Single Radionuclide Soil Guidelines 18
Dose Per Nuclide Summed Over All Pathways 19
Soil Concentration Per Nuclide 19

Attachment	1	Sheet No.	1 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  07:12  Page   2
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

0 Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(1)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(2)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(3)
A-1	Pa-234 (Source: FGR 12)	1.155E+01	1.155E+01	DCF1(4)
A-1	Pa-234m (Source: FGR 12)	8.967E-02	8.967E-02	DCF1(5)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(6)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(7)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(8)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(9)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(10)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(11)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(12)
A-1	Th-230 (Source: FGR 12)	1.209E-03	1.209E-03	DCF1(13)
A-1	Th-234 (Source: FGR 12)	2.410E-02	2.410E-02	DCF1(14)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(15)
A-1	U-234 (Source: FGR 12)	4.017E-04	4.017E-04	DCF1(16)
A-1	U-238 (Source: FGR 12)	1.031E-04	1.031E-04	DCF1(17)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(1)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(2)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(3)
B-1	U-234	1.320E-01	1.320E-01	DCF2(4)
B-1	U-238	1.180E-01	1.180E-01	DCF2(5)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(6)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(1)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(2)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(3)
D-1	U-234	2.830E-04	2.830E-04	DCF3(4)
D-1	U-238	2.550E-04	2.550E-04	DCF3(5)
D-1	U-238+D	2.687E-04	2.550E-04	DCF3(6)
D-34	Food transfer factors:			
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(1,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(1,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(1,3)
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(2,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,3)
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(3,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(3,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(3,3)

Attachment	1	Sheet No.	2 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  07:12  Page   3
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: FGR 12 & FGR 11

0 Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(4,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(4,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(4,3)
D-34				
D-34	U-238 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(5,1)
D-34	U-238 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(5,2)
D-34	U-238 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(5,3)
D-34				
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(6,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(6,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(6,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(1,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(2,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(2,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(3,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(3,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(4,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(4,2)
D-5				
D-5	U-238 , fish	1.000E+01	1.000E+01	BIOFAC(5,1)
D-5	U-238 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(5,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(6,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(6,2)

#For DCF1(xxx) only, factors are for infinite depth & area. See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.

Attachment 1 Sheet No. 3 of 19
Originator: S. W. Clark Date 2/17/11
Chk'd By M. W. Perrott Date 2/17/11
Calc. No. 0600Y.CA.V0107 Rev. No. 0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  07:12  Page   4
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Site-Specific Parameter Summary

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	9.000E+02	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.000E+00	2.000E+00	---	THICKO
R011	Fraction of contamination that is submerged	0.000E+00	0.000E+00	---	SUBMFRACT
R011	Length parallel to aquifer flow (m)	3.000E+01	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	1.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	4.870E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): U-238	2.200E+00	0.000E+00	---	S1(5)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(5)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVERO
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	0.000E+00	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	1.500E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	2.500E+02	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	4.050E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	3.400E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	9.100E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.600E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	7.600E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	2.500E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	1.500E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	5.530E+03	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	1.250E-03	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	0.000E+00	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	4.600E+00	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW

Attachment 1 Sheet No. 4 of 19
Originator: S. W. Clark Date 2/17/11
Chk'd By M. W. Perrott Date 2/17/11
Calc. No. 0600X-CA-V0107 Rev. No. 0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  07:12  Page   5
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	1.200E+01	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.600E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	1.500E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.500E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	4.050E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	2.500E+02	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	5.000E+00	5.000E+01	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+00	5.000E+01	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	5.000E+00	5.000E+01	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	9.754E-03	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.989E-04	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	7.123E-04	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for daughter Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.325E-07	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for daughter U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	9.966E-04	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R017	Inhalation rate (m**3/yr)	not used	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	not used	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	not used	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	not used	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	not used	5.000E-01	---	FIND

Attachment	1	Sheet No.	5 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 07:12 Page 6
Summary : 600-323 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fraction of time spent outdoors (on site)	not used	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	not used	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	not used	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	7.300E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5

Attachment 1 Sheet No. 6 of 19
Originator: S. W. Clark Date 2/17/11
Chk'd By M. W. Perrott Date 2/17/11
Calc. No. 0600X-CA-V0107 Rev. No. 0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  07:12  Page   7
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	not used	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL

Attachment 1 Sheet No. 7 of 19
Originator: S. W. Clark Date 2/17/11
Chk'd By M. W. Perrott Date 2/17/11
Calc. No. 0600X-CA-V0107 Rev. No. 0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  07:12  Page   8
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	1	---	---	LYMAX
TITL	Maximum number of integration points for risk	5	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	suppressed
2 -- inhalation (w/o radon)	suppressed
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	active
8 -- soil ingestion	suppressed
9 -- radon	suppressed
Find peak pathway doses	suppressed

Attachment	1	Sheet No.	8 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  07:12  Page   9
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

      Contaminated Zone Dimensions           Initial Soil Concentrations, pCi/g
      ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ           ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
        Area:     900.00 square meters              U-238      2.200E+00
   Thickness:       1.00 meters
 Cover Depth:       0.00 meters
0
                                  Total Dose TDOSE(t), mrem/yr
                            Basic Radiation Dose Limit = 1.500E+01 mrem/yr
             Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)
             ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
    t (years):  0.000E+00  1.000E+00  3.000E+00  1.000E+01  3.000E+01  1.000E+02  4.870E+02  1.000E+03
     TDOSE(t):  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  5.627E+00  3.859E-02
         M(t):  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  3.751E-01  2.573E-03
0Maximum TDOSE(t):  5.680E+00 mrem/yr    at t =    487.6 ñ 1.0 years
0
                          Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                                  As mrem/yr and Fraction of Total Dose At t = 4.876E+02 years
0                                   Water Independent Pathways (Inhalation excludes radon)
0           Ground           Inhalation          Radon             Plant              Meat              Milk              Soil
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.  mrem/yr  fract.  mrem/yr  fract.  mrem/yr  fract.  mrem/yr  fract.  mrem/yr  fract.  mrem/yr  fract.
 Nuclide
ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ
 U-238   0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000
ÌÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ
 Total   0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000
0
                          Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                                  As mrem/yr and Fraction of Total Dose At t = 4.876E+02 years
0                                                Water Dependent Pathways
0            Water             Fish              Radon             Plant              Meat              Milk          All Pathways*
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.  mrem/yr  fract.  mrem/yr  fract.  mrem/yr  fract.  mrem/yr  fract.  mrem/yr  fract.  mrem/yr  fract.
 Nuclide
ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ
 U-238   5.680E+00 1.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 5.680E+00 1.0000
ÌÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ ÌÌÌÌÌÌÌÌÌ ÌÌÌÌÌÌ
 Total   5.680E+00 1.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 5.680E+00 1.0000
0*Sum of all water independent and dependent pathways.
```

Attachment 1	Sheet No. 9 of 19
Originator: S. W. Clark	Date 2/17/11
Chk'd By M. W. Perrott	Date 2/17/11
Calc. No. 0600X-CA-V0107	Rev. No. 0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  07:12  Page  10
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Attachment	1	Sheet No.	10 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  07:12  Page  11
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

0*Sum of all water independent and dependent pathways.

Attachment	1	Sheet No.	11 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  07:12  Page  12
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Attachment	1	Sheet No.	12 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  07:12  Page  13
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Attachment	1	Sheet No.	13 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  07:12  Page  14
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Attachment	1	Sheet No.	14 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T½ Limit = 180 days        02/16/2011  07:12  Page  15
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

                    Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                              As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
0                                Water Independent Pathways (Inhalation excludes radon)
0            Ground          Inhalation          Radon              Plant              Meat               Milk               Soil
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ
 U-238   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000
 ïïïïïïï ïïïïïïïïïï ïïïïïï ïïïïïïïïïï ïïïïïï ïïïïïïïïïï ïïïïïï ïïïïïïïïïï ïïïïïï ïïïïïïïïïï ïïïïïï ïïïïïïïïïï ïïïïïï
 Total   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000
0

                    Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                              As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
0                                Water Dependent Pathways
0            Water           Fish                Radon              Plant              Meat               Milk               All Pathways*
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ
 U-238   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000
 ïïïïïïï ïïïïïïïïïï ïïïïïï ïïïïïïïïïï ïïïïïï ïïïïïïïïïï ïïïïïï ïïïïïïïïïï ïïïïïï ïïïïïïïïïï ïïïïïï ïïïïïïïïïï ïïïïïï
 Total   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000
0*Sum of all water independent and dependent pathways.
```

Attachment	1	Sheet No.	15 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  07:12  Page  16
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.870E+02 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.870E+02 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	5.627E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.627E+00	1.0000
Total	5.627E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.627E+00	1.0000

*Sum of all water independent and dependent pathways.

Attachment	1	Sheet No.	16 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  07:12  Page  17
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-238	3.859E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.859E-02	1.0000
Total	3.859E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.859E-02	1.0000

0*Sum of all water independent and dependent pathways.

Attachment	1	Sheet No.	17 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T½ Limit = 180 days        02/16/2011  07:12  Page  18
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

                                Dose/Source Ratios Summed Over All Pathways
                          Parent and Progeny Principal Radionuclide Contributions Indicated
0  Parent    Product    Thread                 DSR(j,t) At Time in Years   (mrem/yr)/(pCi/g)
   (i)       (j)       Fraction   0.000E+00 1.000E+00 3.000E+00 1.000E+01 3.000E+01 1.000E+02 4.870E+02 1.000E+03
 ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ
 U-238     U-238     5.400E-05  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.311E-04 8.936E-07
0U-238+D   U-238+D   9.999E-01  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 2.558E+00 1.744E-02
 U-238+D   U-234     9.999E-01  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.022E-05 1.007E-04
 U-238+D   Th-230    9.999E-01  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 6.720E-12 6.531E-10
 U-238+D   Ra-226+D  9.999E-01  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.185E-08 1.790E-07
 U-238+D   Pb-210+D  9.999E-01  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 4.570E-08 6.312E-07
 U-238+D   ãDSR(j)              0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 2.558E+00 1.754E-02
 ßßßßßßßßßß ßßßßßßßßßß ßßßßßßßßß ßßßßßßßßß ßßßßßßßßß ßßßßßßßßß ßßßßßßßßß ßßßßßßßßß ßßßßßßßßß ßßßßßßßßß
 The DSR includes contributions from associated (half-life ó 180 days) daughters.
0
                                Single Radionuclide Soil Guidelines G(i,t) in pCi/g
                                   Basic Radiation Dose Limit = 1.500E+01 mrem/yr
0Nuclide
   (i)     t= 0.000E+00   1.000E+00   3.000E+00   1.000E+01   3.000E+01   1.000E+02   4.870E+02   1.000E+03
 ÄÄÄÄÄÄÄ    ÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄ
 U-238      *3.361E+05  *3.361E+05  *3.361E+05  *3.361E+05  *3.361E+05  *3.361E+05   5.864E+00   8.552E+02
 ßßßßßßß    ßßßßßßßßß  ßßßßßßßßß  ßßßßßßßßß  ßßßßßßßßß  ßßßßßßßßß  ßßßßßßßßß  ßßßßßßßßß  ßßßßßßßßß
 *At specific activity limit
0
            Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
            and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
          at tmin = time of minimum single radionuclide soil guideline
      and at tmax = time of maximum total dose =   487.6 ñ 1.0 years
0Nuclide  Initial        tmin        DSR(i,tmin) G(i,tmin) DSR(i,tmax) G(i,tmax)
   (i)    (pCi/g)      (years)                   (pCi/g)               (pCi/g)
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ
 U-238   2.200E+00    487.6 ñ 1.0     2.582E+00 5.809E+00 2.582E+00 5.809E+00
 ßßßßßßß ßßßßßßßßßß ßßßßßßßßßßßßßßßßß ßßßßßßßßßß ßßßßßßßßßß ßßßßßßßßßß ßßßßßßßßßß
```

Attachment	1	Sheet No.	18 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  07:12  Page  19
 Summary : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

                                Individual Nuclide Dose Summed Over All Pathways
                                 Parent Nuclide and Branch Fraction Indicated
ONuclide Parent   THF(i)                                DOSE(j,t), mrem/yr
   (j)     (i)            t= 0.000E+00 1.000E+00 3.000E+00 1.000E+01 3.000E+01 1.000E+02 4.870E+02 1.000E+03
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ    ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ
 U-238   U-238   5.400E-05    0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 2.884E-04 1.966E-06
 U-238   U-238   9.999E-01    0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 5.627E+00 3.836E-02
 U-238   äDOSE(j)             0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 5.627E+00 3.836E-02
OU-234   U-238   9.999E-01    0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 2.249E-05 2.214E-04
OTh-230  U-238   9.999E-01    0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.478E-11 1.437E-09
ORa-226  U-238   9.999E-01    0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 2.606E-08 3.938E-07
OPb-210  U-238   9.999E-01    0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.005E-07 1.389E-06
 ïïïïïïï ïïïïïïï ïïïïïïïïï    ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï
 THF(i) is the thread fraction of the parent nuclide.


                                Individual Nuclide Soil Concentration
                                 Parent Nuclide and Branch Fraction Indicated
ONuclide Parent   THF(i)                                 S(j,t), pCi/g
   (j)     (i)            t= 0.000E+00 1.000E+00 3.000E+00 1.000E+01 3.000E+01 1.000E+02 4.870E+02 1.000E+03
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ    ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ
 U-238   U-238   5.400E-05    1.188E-04 1.176E-04 1.154E-04 1.078E-04 8.866E-05 4.479E-05 1.028E-06 6.899E-09
 U-238   U-238   9.999E-01    2.200E+00 2.179E+00 2.136E+00 1.995E+00 1.642E+00 8.295E-01 1.903E-02 1.278E-04
 U-238   äS(j):              2.200E+00 2.179E+00 2.137E+00 1.996E+00 1.642E+00 8.295E-01 1.903E-02 1.278E-04
OU-234   U-238   9.999E-01    0.000E+00 6.203E-06 1.841E-05 5.912E-05 1.597E-04 3.760E-04 4.317E-04 2.622E-04
OTh-230  U-238   9.999E-01    0.000E+00 2.797E-11 2.499E-10 2.709E-09 2.273E-08 2.006E-07 1.817E-06 3.380E-06
ORa-226  U-238   9.999E-01    0.000E+00 4.041E-15 1.085E-13 3.935E-12 1.002E-10 3.055E-09 1.465E-07 5.419E-07
OPb-210  U-238   9.999E-01    0.000E+00 3.123E-17 2.486E-15 2.891E-13 1.986E-11 1.465E-09 1.260E-07 5.071E-07
 ïïïïïïï ïïïïïïï ïïïïïïïïï    ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï ïïïïïïïïï
 THF(i) is the thread fraction of the parent nuclide.
ORESCALC.EXE execution time =    6.09 seconds
```

Attachment	1	Sheet No.	19 of 19
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 2

```
1RESRAD, Version 6.5      T½ Limit = 180 days        02/16/2011  07:12  Page   1
 Concent : 600-323 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

                    Table of Contents
                    ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
          Part IV: Concentration of Radionuclides
          ÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ

 Concentration of radionuclides in different media
      Time= 0.000E+00 ..................................   2
      Time= 1.000E+00 ..................................   3
      Time= 3.000E+00 ..................................   4
      Time= 1.000E+01 ..................................   5
      Time= 3.000E+01 ..................................   6
      Time= 1.000E+02 ..................................   7
      Time= 4.870E+02 ..................................   8
      Time= 1.000E+03 ..................................   9
```

Attachment 2 Sheet No. 1 of 9
Originator: S. W. Clark Date 2/17/11
Chk'd By M. W. Perrott Date 2/17/11
Calc. No. 0600X-CA-V0107 Rev. No. 0

ATTACHMENT 2

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  07:12  Page   2 -
Concent : 600-323 Selenium Groundwater and Columbia River Protection
File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Concentration of radionuclides in environmental media
at t = 0.000E+00 years

Radio-Nuclide	Contaminated Zone pCi/g	Surface Soil* pCi/g	Air Particulate pCi/m**3	Well Water pCi/L	Surface Water pCi/L
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Th-230	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
U-234	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
U-238	2.200E+00	2.200E+00	2.149E-05	0.000E+00	0.000E+00

*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media
at t = 0.000E+00 years*

Radio-Nuclide	Drinking Water pCi/L	Nonleafy Vegetable pCi/kg	Leafy Vegetable pCi/kg	Fodder Meat pCi/kg	Fodder Milk pCi/kg	Meat pCi/kg	Milk pCi/L	Fish pCi/kg	Crustacea pCi/kg
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Th-230	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
U-234	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
U-238	0.000E+00	5.501E+00	5.506E+00	5.506E+00	5.506E+00	5.013E-01	8.417E-01	0.000E+00	0.000E+00

*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Attachment	2	Sheet No.	2 of 9
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 2

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 07:12 Page 3
Concent : 600-323 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

Concentration of radionuclides in environmental media
at t = 1.000E+00 years

Radio-Nuclide	Contaminated Zone pCi/g	Surface Soil* pCi/g	Air Particulate pCi/m**3	Well Water pCi/L	Surface Water pCi/L
Pb-210	3.123E-17	3.123E-17	3.051E-22	0.000E+00	0.000E+00
Ra-226	4.041E-15	4.041E-15	3.948E-20	0.000E+00	0.000E+00
Th-230	2.797E-11	2.797E-11	2.732E-16	0.000E+00	0.000E+00
U-234	6.203E-06	6.203E-06	6.060E-11	0.000E+00	0.000E+00
U-238	2.179E+00	2.179E+00	2.128E-05	0.000E+00	0.000E+00

*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media
at t = 1.000E+00 years*

Radio-Nuclide	Drinking Water pCi/L	Nonleafy Vegetable pCi/kg	Leafy Vegetable pCi/kg	Fodder Meat pCi/kg	Fodder Milk pCi/kg	Meat pCi/kg	Milk pCi/L	Fish pCi/kg	Crustacea pCi/kg
Pb-210	0.000E+00	4.389E-16	3.227E-16	4.884E-16	5.973E-16	4.998E-17	1.517E-17	0.000E+00	0.000E+00
Ra-226	0.000E+00	1.444E-13	1.604E-13	9.129E-14	1.096E-13	7.958E-15	8.031E-15	0.000E+00	0.000E+00
Th-230	0.000E+00	3.114E-11	2.827E-11	3.419E-11	3.756E-11	2.160E-12	1.383E-13	0.000E+00	0.000E+00
U-234	0.000E+00	1.551E-05	1.552E-05	1.468E-05	1.549E-05	1.414E-06	2.373E-06	0.000E+00	0.000E+00
U-238	0.000E+00	5.450E+00	5.452E+00	5.462E+00	5.459E+00	4.969E-01	8.338E-01	0.000E+00	0.000E+00

*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Attachment 2 Sheet No. 3 of 9
Originator: S. W. Clark Date 2/17/11
Chk'd By M. W. Perrott Date 2/17/11
Calc. No. 0600X-CA-V0107 Rev. No. 0

ATTACHMENT 2

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 07:12 Page 4
Concent : 600-323 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

Concentration of radionuclides in environmental media
at t = 3.000E+00 years

Radio-Nuclide	Contaminated Zone pCi/g	Surface Soil* pCi/g	Air Particulate pCi/m**3	Well Water pCi/L	Surface Water pCi/L
Pb-210	2.486E-15	2.486E-15	2.429E-20	0.000E+00	0.000E+00
Ra-226	1.085E-13	1.085E-13	1.060E-18	0.000E+00	0.000E+00
Th-230	2.499E-10	2.499E-10	2.442E-15	0.000E+00	0.000E+00
U-234	1.841E-05	1.841E-05	1.799E-10	0.000E+00	0.000E+00
U-238	2.137E+00	2.137E+00	2.087E-05	0.000E+00	0.000E+00

*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media
at t = 3.000E+00 years*

Radio-Nuclide	Drinking Water pCi/L	Nonleafy Vegetable pCi/kg	Leafy Vegetable pCi/kg	Fodder Meat pCi/kg	Fodder Milk pCi/kg	Meat pCi/kg	Milk pCi/L	Fish pCi/kg	Crustacea pCi/kg
Pb-210	0.000E+00	2.857E-14	2.514E-14	3.326E-14	3.550E-14	3.236E-15	9.798E-16	0.000E+00	0.000E+00
Ra-226	0.000E+00	4.180E-12	4.328E-12	3.627E-12	3.830E-12	2.983E-13	2.648E-13	0.000E+00	0.000E+00
Th-230	0.000E+00	2.595E-10	2.513E-10	2.711E-10	2.802E-10	1.594E-11	8.743E-13	0.000E+00	0.000E+00
U-234	0.000E+00	4.604E-05	4.607E-05	4.526E-05	4.604E-05	4.196E-06	7.044E-06	0.000E+00	0.000E+00
U-238	0.000E+00	5.345E+00	5.347E+00	5.357E+00	5.354E+00	4.873E-01	8.177E-01	0.000E+00	0.000E+00

*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Attachment	2	Sheet No.	4 of 9
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 2

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 07:12 Page 5
Concent : 600-323 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

Concentration of radionuclides in environmental media
at t = 1.000E+01 years

Radio-Nuclide	Contaminated Zone pCi/g	Surface Soil* pCi/g	Air Particulate pCi/m**3	Well Water pCi/L	Surface Water pCi/L
Pb-210	2.891E-13	2.891E-13	2.824E-18	0.000E+00	0.000E+00
Ra-226	3.935E-12	3.935E-12	3.844E-17	0.000E+00	0.000E+00
Th-230	2.709E-09	2.709E-09	2.646E-14	0.000E+00	0.000E+00
U-234	5.912E-05	5.912E-05	5.776E-10	0.000E+00	0.000E+00
U-238	1.996E+00	1.996E+00	1.950E-05	0.000E+00	0.000E+00

*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media
at t = 1.000E+01 years*

Radio-Nuclide	Drinking Water pCi/L	Nonleafy Vegetable pCi/kg	Leafy Vegetable pCi/kg	Fodder Meat pCi/kg	Fodder Milk pCi/kg	Meat pCi/kg	Milk pCi/L	Fish pCi/kg	Crustacea pCi/kg
Pb-210	0.000E+00	3.030E-12	2.902E-12	3.256E-12	3.321E-12	3.104E-13	9.898E-14	0.000E+00	0.000E+00
Ra-226	0.000E+00	1.557E-10	1.573E-10	1.494E-10	1.517E-10	1.210E-11	1.031E-11	0.000E+00	0.000E+00
Th-230	0.000E+00	2.741E-09	2.718E-09	2.784E-09	2.813E-09	1.595E-10	8.099E-12	0.000E+00	0.000E+00
U-234	0.000E+00	1.478E-04	1.480E-04	1.472E-04	1.479E-04	1.347E-05	2.262E-05	0.000E+00	0.000E+00
U-238	0.000E+00	4.992E+00	4.994E+00	5.003E+00	5.001E+00	4.551E-01	7.637E-01	0.000E+00	0.000E+00

*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Attachment	2	Sheet No.	5 of 9
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 2

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  07:12  Page   6
Concent : 600-323 Selenium Groundwater and Columbia River Protection
File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD
```

Concentration of radionuclides in environmental media
at t = 3.000E+01 years

Radio-Nuclide	Contaminated Zone pCi/g	Surface Soil* pCi/g	Air Particulate pCi/m**3	Well Water pCi/L	Surface Water pCi/L
Pb-210	1.986E-11	1.986E-11	1.940E-16	0.000E+00	0.000E+00
Ra-226	1.002E-10	1.002E-10	9.792E-16	0.000E+00	0.000E+00
Th-230	2.273E-08	2.273E-08	2.221E-13	0.000E+00	0.000E+00
U-234	1.597E-04	1.597E-04	1.560E-09	0.000E+00	0.000E+00
U-238	1.642E+00	1.642E+00	1.604E-05	0.000E+00	0.000E+00

*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media
at t = 3.000E+01 years*

Radio-Nuclide	Drinking Water pCi/L	Nonleafy Vegetable pCi/kg	Leafy Vegetable pCi/kg	Fodder Meat pCi/kg	Fodder Milk pCi/kg	Meat pCi/kg	Milk pCi/L	Fish pCi/kg	Crustacea pCi/kg
Pb-210	0.000E+00	2.022E-10	1.989E-10	2.086E-10	2.099E-10	1.974E-11	6.463E-12	0.000E+00	0.000E+00
Ra-226	0.000E+00	3.995E-09	4.008E-09	3.942E-09	3.962E-09	3.179E-10	2.680E-10	0.000E+00	0.000E+00
Th-230	0.000E+00	2.283E-08	2.280E-08	2.298E-08	2.306E-08	1.307E-09	6.467E-11	0.000E+00	0.000E+00
U-234	0.000E+00	3.993E-04	3.996E-04	3.991E-04	3.997E-04	3.639E-05	6.110E-05	0.000E+00	0.000E+00
U-238	0.000E+00	4.107E+00	4.109E+00	4.116E+00	4.114E+00	3.744E-01	6.284E-01	0.000E+00	0.000E+00

*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Attachment	2	Sheet No.	6 of 9
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 2

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 07:12 Page 7
Concent : 600-323 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

Concentration of radionuclides in environmental media
at t = 1.000E+02 years

Radio-Nuclide	Contaminated Zone pCi/g	Surface Soil* pCi/g	Air Particulate pCi/m**3	Well Water pCi/L	Surface Water pCi/L
Pb-210	1.465E-09	1.465E-09	1.431E-14	0.000E+00	0.000E+00
Ra-226	3.055E-09	3.055E-09	2.984E-14	0.000E+00	0.000E+00
Th-230	2.006E-07	2.006E-07	1.960E-12	0.000E+00	0.000E+00
U-234	3.760E-04	3.760E-04	3.674E-09	0.000E+00	0.000E+00
U-238	8.295E-01	8.295E-01	8.104E-06	0.000E+00	0.000E+00

*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media
at t = 1.000E+02 years*

Radio-Nuclide	Drinking Water pCi/L	Nonleafy Vegetable pCi/kg	Leafy Vegetable pCi/kg	Fodder Meat pCi/kg	Fodder Milk pCi/kg	Meat pCi/kg	Milk pCi/L	Fish pCi/kg	Crustacea pCi/kg
Pb-210	0.000E+00	1.476E-08	1.466E-08	1.497E-08	1.500E-08	1.414E-09	4.678E-10	0.000E+00	0.000E+00
Ra-226	0.000E+00	1.221E-07	1.222E-07	1.216E-07	1.218E-07	9.794E-09	8.225E-09	0.000E+00	0.000E+00
Th-230	0.000E+00	2.009E-07	2.012E-07	2.016E-07	2.018E-07	1.144E-08	5.606E-10	0.000E+00	0.000E+00
U-234	0.000E+00	9.403E-04	9.410E-04	9.410E-04	9.412E-04	8.569E-05	1.439E-04	0.000E+00	0.000E+00
U-238	0.000E+00	2.075E+00	2.076E+00	2.080E+00	2.079E+00	1.892E-01	3.175E-01	0.000E+00	0.000E+00

*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Attachment	2	Sheet No.	7 of 9
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

ATTACHMENT 2

1RESRAD, Version 6.5 T½ Limit = 180 days 02/16/2011 07:12 Page 8
Concent : 600-323 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

Concentration of radionuclides in environmental media
at t = 4.870E+02 years

Radio-Nuclide	Contaminated Zone pCi/g	Surface Soil* pCi/g	Air Particulate pCi/m**3	Well Water pCi/L	Surface Water pCi/L
Pb-210	1.260E-07	1.260E-07	1.230E-12	1.885E-08	2.250E-10
Ra-226	1.465E-07	1.465E-07	1.432E-12	2.692E-08	3.213E-10
Th-230	1.817E-06	1.817E-06	1.775E-11	3.414E-11	4.075E-13
U-234	4.317E-04	4.317E-04	4.217E-09	1.087E-04	1.297E-06
U-238	1.903E-02	1.903E-02	1.859E-07	2.869E+01	3.424E-01

*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media
at t = 4.870E+02 years*

Radio-Nuclide	Drinking Water pCi/L	Nonleafy Vegetable pCi/kg	Leafy Vegetable pCi/kg	Fodder Meat pCi/kg	Fodder Milk pCi/kg	Meat pCi/kg	Milk pCi/L	Fish pCi/kg	Crustacea pCi/kg
Pb-210	1.893E-08	1.291E-06	1.380E-06	1.402E-06	1.398E-06	1.280E-07	4.290E-08	6.928E-08	2.314E-08
Ra-226	2.702E-08	5.898E-06	6.033E-06	6.036E-06	6.031E-06	4.851E-07	4.093E-07	1.649E-08	8.246E-08
Th-230	3.696E-11	1.818E-06	1.822E-06	1.824E-06	1.824E-06	1.033E-07	5.049E-09	4.408E-11	2.226E-10
U-234	1.089E-04	1.226E-03	1.767E-03	1.888E-03	1.891E-03	1.197E-04	2.024E-04	1.313E-05	7.879E-05
U-238	2.869E+01	3.765E+01	1.805E+02	1.964E+02	1.968E+02	5.030E+00	9.254E+00	3.422E+00	2.053E+01

*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Attachment 2 Sheet No. 8 of 9
Originator: S. W. Clark Date 2/17/11
Chk'd By M. W. Perrott Date 2/17/11
Calc. No. 06000Y-CA-V0107 Rev. No. 0

ATTACHMENT 2

1RESRAD, Version 6.5 T∝ Limit = 180 days 02/16/2011 07:12 Page 9
Concent : 600-323 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-323_SELENIUM.RAD

Concentration of radionuclides in environmental media
at t = 1.000E+03 years

Radio-Nuclide	Contaminated Zone pCi/g	Surface Soil* pCi/g	Air Particulate pCi/m**3	Well Water pCi/L	Surface Water pCi/L
Pb-210	5.071E-07	5.071E-07	4.954E-12	2.614E-07	3.120E-09
Ra-226	5.419E-07	5.419E-07	5.294E-12	4.084E-07	4.875E-09
Th-230	3.380E-06	3.380E-06	3.302E-11	3.565E-09	4.255E-11
U-234	2.622E-04	2.622E-04	2.561E-09	1.072E-03	1.279E-05
U-238	1.278E-04	1.278E-04	1.248E-09	1.956E-01	2.334E-03

*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media
at t = 1.000E+03 years*

Radio-Nuclide	Drinking Water pCi/L	Nonleafy Vegetable pCi/kg	Leafy Vegetable pCi/kg	Fodder Meat pCi/kg	Fodder Milk pCi/kg	Meat pCi/kg	Milk pCi/L	Fish pCi/kg	Crustacea pCi/kg
Pb-210	2.614E-07	5.435E-06	6.720E-06	6.940E-06	6.941E-06	5.932E-07	2.033E-07	9.356E-07	3.126E-07
Ra-226	4.084E-07	2.222E-05	2.426E-05	2.449E-05	2.449E-05	1.956E-06	1.683E-06	2.437E-07	1.219E-06
Th-230	3.592E-09	3.387E-06	3.411E-06	3.423E-06	3.423E-06	1.924E-07	9.405E-09	4.277E-09	2.141E-08
U-234	1.072E-03	2.063E-03	7.401E-03	8.046E-03	8.046E-03	2.488E-04	4.471E-04	1.279E-04	7.677E-04
U-238	1.956E-01	2.572E-01	1.231E+00	1.351E+00	1.350E+00	3.458E-02	6.337E-02	2.335E-02	1.401E-01

*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Attachment	2	Sheet No.	9 of 9
Originator:	S. W. Clark	Date	2/17/11
Chk'd By	M. W. Perrott	Date	2/17/11
Calc. No.	0600X-CA-V0107	Rev. No.	0

APPENDIX C

DATA QUALITY ASSESSMENT

APPENDIX C

DATA QUALITY ASSESSMENT

CONFIRMATORY SAMPLING

A data quality assessment (DQA) was performed to compare the confirmatory sampling approach and resulting analytical data with the sampling and data requirements specified in the site-specific sample design (WHC 2010b). This DQA was performed in accordance with site-specific data quality objectives found in the *100 Area Remedial Action Sampling and Analysis Plan* (SAP) (DOE-RL 2009).

A review of the sample design (WCH 2010b), the field logbooks (WCH 2010a), and applicable analytical data packages has been performed as part of this DQA. All samples were collected and analyzed per the sample design. To ensure quality data, the SAP data assurance requirements and the data validation procedure for chemical analysis (BHI 2000) are used as appropriate. This review involves evaluation of the data to determine if they are of the right type, quality, and quantity to support the intended use (i.e., closeout decisions). The DQA completes the data life cycle (i.e., planning, implementation, and assessment) that was initiated by the data quality objectives process (EPA 2006).

Sample data collected at the 600-323 waste site were provided by the laboratories in three sample delivery groups (SDGs): SDG J00908, J00912, and J00913. SDG J00912 was submitted for third-party validation. Samples in the 600-323 waste site data set were analyzed using U.S. Environmental Protection Agency (EPA) method 6010 [inductively coupled plasma (ICP) metals], EPA method 7471 [cold vapor atomic absorption (mercury)], SW-846 Method 3550C [total petroleum hydrocarbons (TPH)] and EPA method 8310 [polycyclic aromatic hydrocarbons (PAH)]. The ICP metals include: antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, silver, vanadium, and zinc.

No major deficiencies were found in any of the SDGs. Minor deficiencies are discussed by SDG as follows below. If no comments are made about a specific analysis it should be assumed that no deficiencies in the quality of the data were found. Unless otherwise noted deficiencies listed below are specific to the individual SDG, but apply to all samples within that SDG.

Minor Deficiencies

SDG J00912

Sample delivery group J00912 comprises two soil samples (J1C2J0 and J1C2J1) from the surface of the 600-323 waste site. Sample J1C2J1 is the field duplicate of sample J1C2J0. SDG J00912 was submitted for formal third-party validation. Minor deficiencies are as follows:

In the TPH analysis, the matrix spike (MS) and matrix spike duplicate (MSD) recoveries for motor oil in sample J1C2J1 (124% and 116%, respectively) were above the laboratory acceptance criteria (57-115%). Analytical results for motor oil in sample J1CMP1 may be considered estimated. Estimated data are useable for decision making purposes.

In the ICP metals analysis, the laboratory has performed a serial dilution on samples J1C2J0 and J1C2J1. The laboratories evaluation of this data indicates that physical or chemical interferences of copper, silicon, and zinc are present within the sample matrix. The laboratory has qualified these data with "L" flags to indicate this interference. Analytical results for cobalt, silicon, and zinc in samples J1C2J0 and J1C2J1 may be considered estimated. Estimated data are useable for decision-making purposes.

In the ICP metals analysis, the MS recoveries for six analytes were out of laboratory acceptance criteria: antimony (37%), chromium (68%), magnesium (66%), molybdenum (69%), silicon (25%), and zinc (57%). Third-party validation has qualified the antimony, chromium, magnesium, molybdenum, silicon, and zinc results in SDG J00912 as estimated with "J" flags. Estimated data are useable for decision-making purposes.

In the ICP metals analysis, the laboratory control standard (LCS) recovery was below project control limits (70-130%) for silicon (44%). Third party validation qualified all silicon results in SDG J00912 as estimated with "J" flags. Estimated data are useable for decision-making purposes.

In the ICP metals analysis, the relative percent differences (RPDs) calculated using the laboratory duplicate were above the project control limits (0-30%) for barium (37%), boron (36%), silicon (44%), sodium (46%), and zinc (42%), respectively. Elevated RPDs in environmental samples are generally attributed to natural heterogeneities in the sample matrix rather than to analytical variability in the sample extraction or analysis process. Third party validation qualified all barium, boron, silicon, sodium, and zinc results in SDG J00912 as estimated with "J" flags. The RPDs for cadmium (49%), lead (32%), and molybdenum (35%) also exceeded project control limits, but were not qualified by third-party validation. All cadmium, lead, and molybdenum results in SDG J00912 may be considered estimated. Estimated data are useable for decision-making purposes.

SDG J00908

This SDG comprises two soil samples (J1CMP0-1) from the 600-323 waste site. Sample J1CMP0 is the equipment blank. Minor deficiencies are as follows:

In the ICP metals analysis, the laboratory has performed a serial dilution on samples J1CMP0 and J1CMP1. The laboratories evaluation of this data indicates that physical or chemical interferences of copper are present within the sample matrix. The laboratory has qualified these data with "L" flags to indicate this interference. Analytical results for cobalt in samples J1CMP0 and J1CMP1 may be considered estimated. Estimated data are useable for decision-making purposes.

In the ICP metals analysis, the MS recoveries for four analytes were out of project acceptance criteria (70-130%). For all of the analytes with MS recoveries outside the acceptance criteria, except antimony and silicon, the initial matrix spike concentrations were not significantly large when compared to the native concentration in the sample. Therefore, the deficiency in the MS result is a reflection of the analytical variability of the native concentration rather than a measure of the recovery from the sample. The original MS recoveries for antimony (51%) and silicon (36%) cannot be attributed to insufficient spike amounts. The antimony and silicon results in SDG J00908 may be considered estimated. Estimated data are useable for decision-making purposes.

In the ICP metals analysis, the RPD calculated using the laboratory duplicate was above the project control limits (0-30%) for cadmium (35%). Elevated RPDs in environmental samples are generally attributed to natural heterogeneities in the sample matrix rather than to analytical variability in the sample extraction or analysis process. All cadmium results in SDG J00908 may be considered estimated. Estimated data are useable for decision-making purposes.

SDG J00913

This SDG comprises three soil samples (J1CMP2-4) from the 600-323 waste site. Minor deficiencies are as follows:

In the ICP metals analysis, the laboratory has performed a serial dilution on samples J1CMP2-4. The laboratories evaluation of this data indicates that physical or chemical interferences of aluminum, barium, calcium, chromium, copper, iron, magnesium, manganese, nickel, silicon, and vanadium are present within the sample matrix. The laboratory has qualified these data with "L" flags to indicate this interference. Analytical results for these analytes in samples J1CMP2, J1CMP3, and J1CMP4 may be considered estimated. Estimated data are useable for decision-making purposes.

In the ICP metals analysis, the MS recoveries for twelve analytes were out of project acceptance criteria (70-130%). For two of the analytes with MS recoveries outside the acceptance criteria, the initial MS concentrations were not significantly large when compared to the native concentration in the sample. Therefore, the deficiency in the MS result is a reflection of the analytical variability of the native concentration rather than a measure of the recovery from the sample. However, the original MS recoveries for antimony (43%), arsenic (68%), beryllium (62%), chromium (62%), cobalt (61%), copper (67%), magnesium (67%), molybdenum (63%), nickel (60%), and silicon (21%) cannot be attributed to insufficient spike amounts. The results for these analytes in SDG J00913 may be considered estimated. Estimated data are useable for decision-making purposes.

In the ICP metals analysis, the RPD calculated using the laboratory duplicate was above the project control limits (0-30%) for barium (39%), boron (52%), calcium (32%), silicon (53%), and zinc (34%). Elevated RPDs in environmental samples are generally attributed to natural heterogeneities in the sample matrix rather than to analytical variability in the sample extraction or analysis process. All barium, boron, calcium, silicon, and zinc results in SDG J00913 may be considered estimated. Estimated data are useable for decision-making purposes.

FIELD QUALITY ASSURANCE/QUALITY CONTROL

Relative Percent Difference (RPD) evaluations of main sample(s) versus the laboratory duplicate(s) are routinely performed and reported by the laboratory. Any deficiencies in those calculations are reported by SDG in the previous sections.

Field quality assurance/quality control (QA/QC) measures are used to assess potential sources of error and cross contamination of samples that could bias results. A single set of field QA/QC samples (main sample and duplicate) were collected, as documented in the field logbook (WCH 2010a). Sample J1C2J0 is the main sample and J1C2J1 is the field duplicate for the surface sample.

The RPDs for the main and field duplicate samples have been calculated and are presented in Appendix A. The entire sample data set including the duplicate sample data are presented as an attachment to the RPD calculation.

Field duplicate samples provide a relative measure of the degree of local heterogeneity in the sampling medium, unlike laboratory duplicates that are used to evaluate precision in the analytical process. The field duplicates are evaluated by computing the RPD of the sample/duplicate pair(s), for each contaminant of concern. No major deficiencies in the RPD calculations were found for the duplicate samples.

There was only one minor deficiency noted in the field duplicate evaluation for the surface sample at the 600-323 waste site. The RPD calculated for silicon (61.8%) was above the field duplicate acceptance criteria (less than 30%). Elevated RPDs in environmental samples are generally attributed to natural heterogeneity in the sample matrix. The data are useable for decision-making purposes.

A secondary check of the data variability is used when one or both of the samples being evaluated (main and duplicate) is less than five times the target detection limit (TDL), including undetected analytes. In these cases, a control limit of $\pm$ 2 times the TDL is used (Appendix A) to indicate that a visual check of the data is required by the review. This case did not apply to any of the sample results. A visual inspection of all of the data is also performed. No additional major or minor deficiencies are noted. The data are useable for decision-making purposes.

SUMMARY

Limited, random, or sample matrix-specific influenced batch QC issues such as those discussed above are a potential for any analysis. The number and types seen in these data sets are within expectations for the matrix types and analyses performed. The DQA review of the 600-323 confirmatory sampling data found that the analytical results are accurate within the standard errors associated with the analytical methods, sampling, and sample handling.

The DQA review for the 600-323 waste site concludes that the reviewed data are of the right type, quality, and quantity to support the intended use. Detection limits, precision, accuracy, and sampling data group completeness were assessed to determine if any analytical results should be rejected as a result of QA and QC deficiencies. The analytical data were found acceptable for decision-making purposes. The confirmatory sample analytical data are stored in the Environmental Restoration (ENRE) project-specific database prior to being submitted for inclusion in the Hanford Environmental Information System (HEIS) database. The confirmatory sample analytical data are also summarized in Appendix A.

REFERENCES

BHI, 2000, *Data Validation Procedure for Chemical Analysis*, BHI-01435, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 2009, *100 Area Remedial Action Sampling and Analysis Plan,* DOE/RL-96-22, Rev. 5, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 2006, *Guidance on Systematic Planning using the Data Quality Objectives Process*, EPA QA/G-4, U.S. Environmental Protection Agency, Office of Environmental Information, Washington, D.C.

WCH, 2010a, *Miscellaneous Sampling*, Logbooks EL-1649, pp. 82 and 86, Washington Closure Hanford, Richland, Washington.

WCH, 2010b, *Work Instruction for Confirmatory Sampling for the 600-323, Bermed Area,* 0600X-WI-G0043, Rev. 0, Washington Closure Hanford, Richland, Washington.