0097106

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

11-AMRC-0156

JUN 09 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 600-315, BLACK GRANULAR STAIN, REVISION 0

Attached for your use is the approved Waste Site Reclassification Form No. 2011-024 and supporting "Remaining Site Verification Package for the 600-315, Black Granular Stain," Revision 0. If you have questions, please contact me or your staff may contact Jamie Zeisloft, of my staff, at (509) 372-0188.

Sincerely,

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
JUN 16 2011
EDMC

100.11.e

Date Submitted: 3/17/2011 Originator: M. L. Proctor Phone: 372-9227	**WASTE SITE RECLASSIFICATION FORM** Operable Unit(s): 100-IU-6 Waste Site Code: 600-315 Type of Reclassification Action: Closed Out ☐ Interim Closed Out ☐ No Action ☒ RCRA Postclosure ☐ Rejected ☐ Consolidated ☐	Control Number: 2011-024

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 600-315, Black Granular Stain waste site is located in the 600 Area in the 100-IU-6 Operable Unit, east of the intersection of F Avenue and Route 2. The site consists of a 4 m (13 ft) black granular surface stained area and underlying soils. This waste site is 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 confirmatory sampling. Confirmatory sampling of this site was performed in November 2010 in accordance with the *Work Instruction for Confirmatory Sampling of the 600-315, Black Granular Stain*, 0600X-WI-G0026, Rev. 0, Washington Closure Hanford, Richland, Washington (WCH 2010b). 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 600-315 waste site to No Action. The current site conditions achieve the remedial action goals established by the Remaining Sites ROD. 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 600-315, Black Granular Stain* (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)	P. Chris Smith for MSF Signature	5/12/11 Date
N/A Ecology Project Manager (printed)	Signature	Date
C. Guzzetti EPA Project Manager (printed)	Signature	5/25/11 Date

REMAINING SITES VERIFICATION PACKAGE FOR THE 600-315, BLACK GRANULAR STAIN

Attachment to Waste Site Reclassification Form 2011-024

March 2011

REMAINING SITES VERIFICATION PACKAGE FOR THE 600-315, BLACK GRANULAR STAIN

EXECUTIVE SUMMARY

The 600-315, Black Granular Stain waste site, located in the 100-IU-6 Operable Unit, consisted of a 4m (13ft)-diameter black granular surface stain. The source of the black surface staining at the 600-315 waste site was unknown.

The 600-315 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 confirmatory sampling. During a site visit in March 2010 it was determined that the black granular material did not appear to be petroleum based, at it was previously suggested in the Waste Information Data System and the Stewardship Information System. Rather, the black granular material appeared to resemble graphite. However, during confirmatory sampling in November 2010, the material was determined to be coal ash. Based on sampling data, Hanford coal ash is not regulated as a dangerous waste. No evidence exists to indicate any dangerous waste was disposed at this site. Focused confirmatory samples were collected to analyze black granular material and the underlying soil in accordance with the *Work Instruction for Confirmatory Sampling of the 600-315, Black Granular Stain* (WCH 2010b). The results indicated that the waste site achieved compliance with the remedial action objectives (RAOs) and remedial action goals (RAGs) for the 600-315 waste site; therefore, remediation was not necessary. A summary of the soil analyses 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 600-315 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 600-315 waste site 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 600-315 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 the 600-315 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.	The hazard quotients for individual nonradionuclide COPCs are <1.	Yes
	Attain a cumulative hazard quotient of <1 for noncarcinogens.	The cumulative hazard quotient for all sampling areas (6.4×10^{-3}) is <1.	
	Attain an excess cancer risk of $<1 \times 10^{-6}$ for individual carcinogens.	No carcinogenic nonradionuclide COPCs were detected above background levels; therefore, the excess cancer risk for individual carcinogens is zero.	
	Attain a cumulative excess cancer risk of $<1 \times 10^{-5}$ for carcinogens.	No carcinogenic nonradionuclide COPCs were subject to the excess cancer risk calculation; therefore, the total excess carcinogenic risk for all sampling areas is zero.	
Groundwater/River Protection – Radionuclides	Attain single COPC groundwater and river RAGs.	Radionuclides were not COPCs for the 600-315 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.	Selenium is present at concentrations above soil RAGs for Columbia River protection. However, based on RESRAD modeling discussed in Appendix C of the RDR/RAWP (DOE-RL2009), it is predicted to be protective of Columbia River for 1,000 years [d].	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), and an evaluation of dilution-attenuation in the saturated zone using the formulas from the EPA *Soil Screening Guidance: User's Guide* (EPA 1996), maximum residual concentrations of selenium are predicted to be protective of Columbia River for 1,000 years (Appendix B). The vadose zone underlying the deepest test pit is approximately 9.1 m (30 ft) thick.

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 boron, selenium, and vanadium. U.S. Environmental Protection Agency ecological soil screening levels were exceeded for cadmium, selenium, and vanadium. Exceeding 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 cadmium and vanadium were below Hanford Site background levels, 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 600-315, BLACK GRANULAR STAIN

STATEMENT OF PROTECTIVENESS

The 600-315, Black Granular Stain 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 600-315 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 boron, selenium, and vanadium. U.S. Environmental Protection Agency ecological soil screening levels were exceeded for cadmium, selenium, and vanadium. Exceeding 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 cadmium and vanadium were below Hanford Site background levels, 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 600-315 waste site, located in the 100-IU-6 Operable Unit, consisted of a 4-m (13-ft)-diameter black granular surface-stained area and underlying soil. There was very little vegetation in the affected area. According to the Waste Information Data System and the Stewardship Information System, the 600-315 waste site was suspected to be associated with the potential presence of petroleum hydrocarbons. However, the site walkdown in March 2010 determined that the black granular material did not appear to be petroleum based; rather, it appeared to resemble graphite.

The site is located approximately 0.5 km (0.3 m) north and 31 m (102 ft) east of the intersection of F Avenue and Route 2 (Figure 1). The Washington State Plane coordinates for this site are N 145384.4, E 580675.8. A gravel pit is located within 100 m east of the 600-315 waste site (Figure 2). Figure 3 shows pre-confirmatory sampling conditions of the waste site.

Figure 1. The 600-315 Waste Site Location Map.

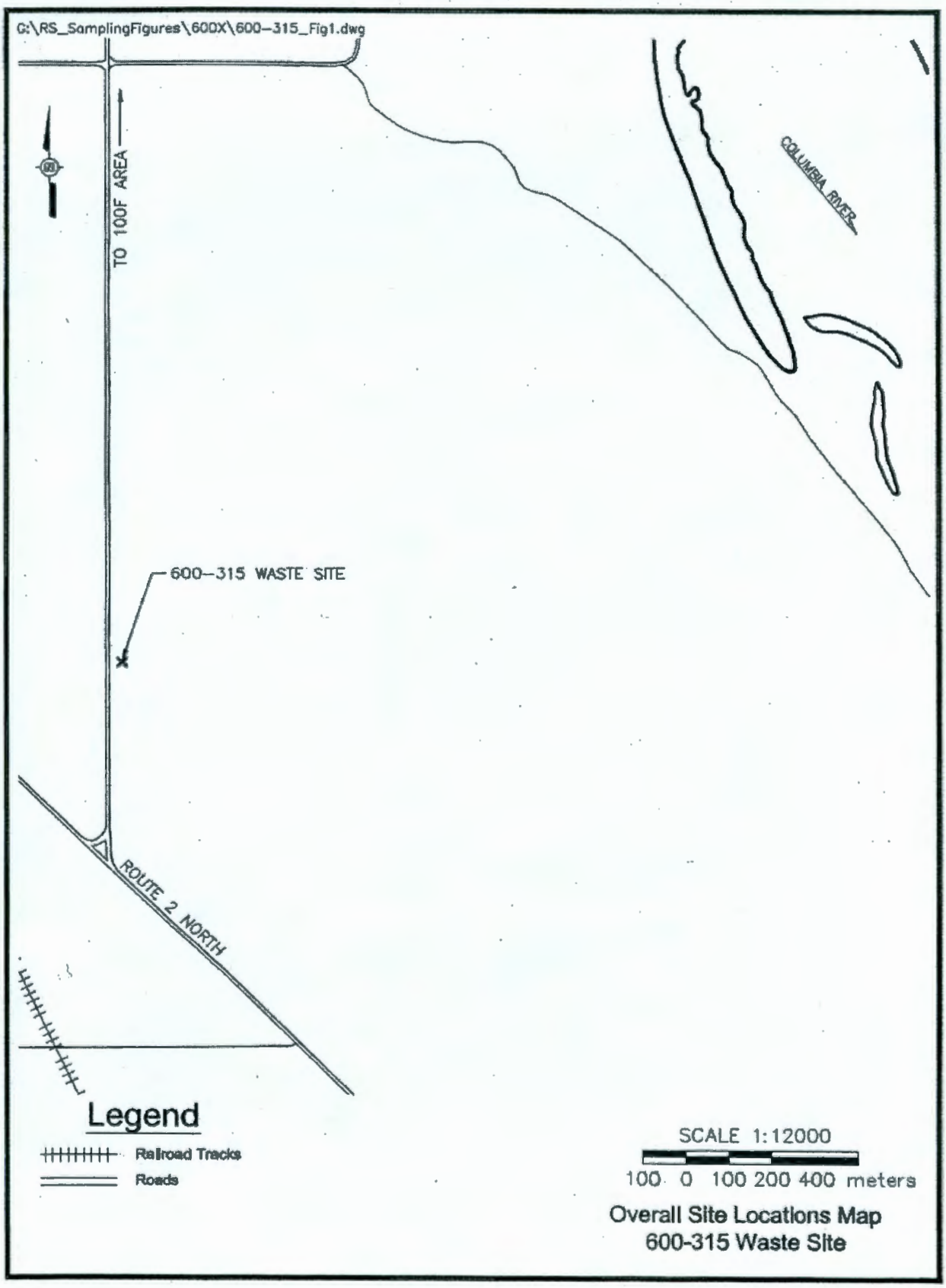

Figure 2. Aerial Photograph Showing the 600-315 Waste Site and Gravel Pit (2009).

Figure 3. Photograph Showing 600-315, Black Granular Stain (March 15, 2010).

Large portions of the areas included in the 100-IU-2 and 100-IU-6 orphan sites evaluation (WCH 2009) consisted of pre-Manhattan Project farmsteads. These farmstead communities existed from 1880 to 1943, and their locations within the Columbia River corridor are known from historical records. Based on information collected to date, the farmstead remains include small quantities of petroleum materials and materials identified as hazardous in the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (e.g., empty pesticide containers, paint cans) intermixed with larger amounts of debris (e.g., wood, fencing, concrete, glass). The remains appear to present little risk to human health or the environment in their present configuration (WCH 2009). The source of the black surface staining at the 600-315 waste site is unknown. It is possibly related to historical farmstead activities or may be associated with early use of the nearby gravel pit.

CONFIRMATORY SAMPLING SUMMARY

The 600-315 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 of the black granular material and the underlying soil were used to evaluate the 600-315 waste site. During the confirmatory sampling activities it was determined that the black granular material was coal ash. A focused sample and a duplicate were collected from the black granular material. One additional focused sample was collected from the soil under the black granular material (coal ash). Field surveys for radiological contamination and volatile organic compounds (VOCs) were conducted during sampling. No radiological activity or VOCs were detected. No asbestos-containing materials were identified during sampling activities; therefore, asbestos analysis was not needed.

Confirmatory sampling determined that environmental contamination above the remedial action goals (RAGs) was not present at this waste site. Based on confirmatory sampling at the 600-315 waste site, remedial action was determined to be unnecessary, and the confirmatory sampling data has been used to document this waste site for reclassification as a No Action site. Tables 1 and 2 identify the location and analyses for confirmatory sampling. No anomalous features were identified during confirmatory sampling.

Table 1. 600-315 Confirmatory Sampling Summary Table.

Sample Location	Sample Media	HEIS Number	Washington State Plane Coordinates		Sample Analysis
			Northing (m)	Easting (m)	
Black Granular Material	Black Material	J1C2J8	145384	580676	ICP metals [a], mercury, TPH, PAH, PCBs
Duplicate of	Black material	J1C2K0	145384	580676	
Underlying soil	Underlying soil	J1C2J9	145384	580676	
Equipment blank	Silica sand	J1C2J7	NA	NA	ICP metals [a], mercury

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

HEIS = Hanford Environmental Information System
ICP = inductively coupled plasma
NA = not applicable
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyl
TPH = total petroleum hydrocarbons

Table 2. 600-315 Laboratory Analytical Methods.

Analytical Method	Contaminant of Potential Concern
ICP metals [a] – EPA Method 6010	Expanded list [a]
Mercury – EPA Method 7471	Mercury
PCB – EPA Method 8082	Polychlorinated biphenyls
PAH – EPA Method 8310	Polycyclic aromatic hydrocarbons
TPH – NWTPH-Dx	Petroleum hydrocarbons

[a] Analysis was performed for the expanded list of ICP metals including antimony, arsenic, barium, beryllium, boron, cadmium, chromium (total), cobalt, copper, lead, manganese, molybdenum, nickel, selenium, silver, vanadium, and zinc.

EPA = U.S. Environmental Protection Agency
ICP = inductively coupled plasma
NWTPH-Dx = Northwest total petroleum hydrocarbons – diesel range organics
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyl
TPH = total petroleum hydrocarbons

Contaminants of Potential Concern

The contaminants of potential concern (COPCs) for the 600-315 waste site were determined based on potential hazardous constituents associated with the black granular stain. The COPCs included the expanded list of inductively coupled plasma (ICP) metals, mercury, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAH), and total petroleum hydrocarbons (TPH). Because no suspected asbestos-containing material was observed during confirmatory sampling, analysis was not performed for asbestos. Radiological activity was not detected in the field during confirmatory sampling activities; therefore, analyses for radionuclides were not performed.

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. If no detections for a given COPC were reported in the data set, then no comparisons were performed for that COPC.

Comparisons of the maximum results for COPCs and the site RAGs for the 600-315 waste site are presented in Table 3. Contaminants that were not detected by laboratory analysis are excluded from these tables. 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 tables. 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 different (RPD) calculation in Appendix A.

Table 3. Comparison of Maximum Contaminant Concentrations to Remedial Action Goals for the 600-315 Confirmatory Sampling Data.

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	2.0 (<BG)	20 [b]	20 [b]	20 [b]	No	--
Barium	90.1 (<BG)	5,600	200	400	No	--
Beryllium	0.46 (<BG)	10.4 [c]	1.51 [b]	1.51 [b]	No	--
Boron [d]	13.3	7,200	320	-- [e]	No	--
Cadmium [f]	0.64 (<BG)	13.9 [c]	0.81 [b]	0.81 [b]	No	--
Chromium (total)	5.3 (<BG)	80,000	18.5 [b]	18.5 [b]	No	--
Cobalt	3.5 (<BG)	24	15.7 [b]	-- [e]	No	--
Copper	7.9 (<BG)	2,960	59.2	22.0 [b]	No	--
Lead	7.4 (<BG)	353	10.2 [b]	10.2 [b]	No	--
Manganese	169 (<BG)	3,760	512 [b]	512 [b]	No	--
Mercury	0.017 (<BG)	24	0.33 [b]	0.33 [b]	No	--
Molybdenum [d]	0.41	400	8	-- [e]	No	--
Nickel	4.9 (<BG)	1,600	19.1 [b]	27.4	No	--
Selenium	1.4	400	5	1	Yes	Yes [g]
Vanadium	17.6 (<BG)	560	85.1 [b]	-- [e]	No	--
Zinc	24.2 (<BG)	24,000	480	67.8 [b]	No	--
Acenaphthylene [h]	0.048	4,800	96	129	No	--
Phenanthrene [h]	0.067	24,000	240	1,920	No	--
TPH	110	200	200	200	No	--

[a] RAGs obtained from the RDR/RAWP (DOE-RL 2009) 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-RL 2009).

[c] Carcinogenic cleanup level calculated based on the inhalation exposure pathway per WAC 173-340-750(3), 1996 (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]).

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

[e] 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], 1996 [Method B for surface waters]).

[f] 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).

[g] 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), maximum residual concentrations of selenium are predicted to be protective of groundwater and Columbia River for 1,000 years (Appendix B). The vadose zone underlying the deepest test pit is approximately 9.1 m (30 ft) thick.

[h] Toxicity data for this chemical are not available. Cleanup levels are based on surrogate chemicals:
Contaminant: acenaphthylene; surrogate: acenapthene
Contaminant: phenanthrene; surrogate; anthracene

-- = not applicable
AWQC = ambient water quality criteria
BG = background
COPC = contaminant of potential concern
Ecology = Washington State Department of Ecology
RAG = remedial action goal
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*

DATA EVALUATION

This section demonstrates that contaminant concentrations at the 600-315 waste site achieved 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).

Nonradionuclides 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 600-315 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 600-315 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. The cumulative noncarcinogenic hazard quotient is 6.4×10^{-3}. Because there is no carcinogenic RAG for boron, molybdenum, selenium, acenaphthylene, phenanthrene, or total petroleum hydrocarbons, the total carcinogenic risk is zero.

Nonradionuclide Soil RAGs for Groundwater and River Protection Attained

Selenium was quantified at a concentration exceeding the soil RAG for river protection in the surface sample. Selenium was detected just above the river protection RAG (1.0 mg/kg) at 1.2 mg/kg (main) and 1.4 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. To further support the case that the selenium detection at 600-315 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.

DATA QUALITY ASSESSMENT

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

The DQA for the 600-315 waste site established that the data are of the right type, quality, and quantity to support site closeout 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 600-315 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 remedial action goals and associated remedial action objectives for direct exposure, groundwater protection, and river protection. In accordance with this evaluation, the verification sampling results support a reclassification of the 600-315 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.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq.

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

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.

EPA, 1996, *Soil Screening Guidance: User's Guide*, OSWER 9355.4-23, July 1996, U.S. Environmental Protection Agency, Washington, D.C.

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, 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, 1996, "Model Toxics Control Act – Cleanup," *Washington Administrative Code.*

WCH, 2009, *100-IU-2 and 100-IU-6 Areas Orphan Sites Evaluation Report*, OSR-2008-0001, Rev. 0, Washington Closure Hanford, Richland, Washington.

WCH, 2010a, *100 Area Confirmatory Sampling*, Logbook EL-1649, pp. 81-82, Washington Closure Hanford, Richland, Washington.

WCH, 2010b, *Work Instruction for Confirmatory Sampling of 600-315, Black Granular Stain*, 0600X-WI-G0026, 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: 100-IU-6 Area Confirmatory Sampling **Job No. 14655**

Area: 100-IU-6

Discipline: Environmental Calculation No: 0600X-CA-V0106

Subject: 600-315 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	I. B. Berezovskiy	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:	I. B. Berezovskiy	Date:	2/14/2011	Calc. No.:	0600X-CA-V0106	Rev.:	0
Project:	100-IU-6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	2/14/2011
Subject:	600-315 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 600-315 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 600-315 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 600-315, Black Granular Stain,* Attachment to Waste Site Reclassification Form 2011-024, 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:	I. B. Berezovskiy	Date:	2/14/2011	Calc. No.:	0600X-CA-V0106	Rev.:	0
Project:	100-IU-6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	2/14/2011
Subject:	600-315 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 600-315 waste site was comprised of two surface sample locations for confirmatory sampling. The direct contact hazard quotient and carcinogenic risk calculations for the 600-315 waste site were conservatively calculated for the entire waste site using the two confirmatory soil samples and a duplicate (WCH 2011). Of the contaminants of potential concern (COPCs) for site, selenium required HQ and risk calculations because this analyte was detected above background. In addition, boron, molybdenum, acenaphthylene, and phenanthrene 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 diesel range extended) were detected and no background value is available, the risk 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 13.3 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 1.8×10^{-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 6.4×10^{-3}. 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}. However, because boron, molybdenum, selenium, acenaphthylene, phenenthrene and total petroleum hydrocarbons do not contribute to the cancer risk, the criterion of $<1 \times 10^{-6}$, is met. The sum of the excess cancer risk value is zero. Comparing to the requirement of $<1 \times 10^{-5}$, this criterion is met.

4) 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 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:

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

Washington Closure Hanford, Inc. CALCULATION SHEET

Originator:	I. B. Berezovskiy	Date:	2/14/2011	Calc. No.:	0600X-CA-V0106	Rev.:	0
Project:	100-IU-6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	2/14/2011
Subject:	600-315 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations					Sheet No. 3 of 7	

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 direct contact hazard quotient and excess cancer risk calculations.

Table 2 shows the results of the RPD calculations for the 600-315 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:	I. B. Berezovskiy	Date:	2/14/2011	Calc. No.:	0600X-CA-V0106	Rev.:	0
Project:	100-IU-6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	2/14/2011
Subject:	600-315 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations					Sheet No. 4 of 7	

Table 1. Direct Contact Hazard Quotient and Excess Cancer Risk Results for the 600-315 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					
Boron	13.3	7,200	1.8E-03	--	--
Molybdenum	0.41	400	1.0E-03	--	--
Selenium	1.4	400	3.5E-03	--	--
Polyaromatic Hydrocarbons					
Acenaphthylene[c]	0.048	4,800	1.0E-05	--	--
Phenanthrene[c]	0.067	24,000	2.8E-06	--	--
Total Petroleum Hydrocarbons					
Diesel range - extended [d]	110	200	--	--	--
Totals					
Cumulative Hazard Quotient:			**6.4E-03**		
Cumulative Excess Cancer Risk:					**0.0E+00**

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] = Toxicity data for these chemicals are not available. The cleanup levels are based on use of surrogate chemicals.

acenaphthylene surrogate: acenaphthene

phenanthrene surrogate: anthracene

[d] = The risk 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:	I. B. Berezovskiy	Date:	2/14/2011	Calc. No.:	0600X-CA-V0106	Rev.:	0
Project:	100-IU-6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	2/14/2011
Subject:	600-315 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 600-315 Waste Site. (2 Pages)

600-315 Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Aluminum			Arsenic			Barium		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
Black material	J1C2J8	11/2/2010	2020		1.6	1.8		0.68	90.1		0.078
Duplicate of J1C2J8	J1C2K0	11/2/2010	2140		1.6	2.0		0.70	78.5		0.080

Analysis:

TDL		5	10	2
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)	Yes (continue)
	Both >5xTDL?	Yes (calc RPD)	No-Stop (acceptable)	Yes (calc RPD)
	RPD	5.8%		13.8%
	Difference > 2 TDL?	Not applicable	No - acceptable	Not applicable

600-315 Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Beryllium			Boron			Cadmium		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
Black material	J1C2J8	11/2/2010	0.46		0.034	13.3		1.0	0.64		0.042
Duplicate of J1C2J8	J1C2K0	11/2/2010	0.34		0.035	10.0		1.0	0.37		0.043

Analysis:

TDL		0.2	2	0.2
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)	Yes (continue)
	Both >5xTDL?	No-Stop (acceptable)	No-Stop (acceptable)	No-Stop (acceptable)
	RPD			
	Difference > 2 TDL?	No - acceptable	No - acceptable	No - acceptable

600-315 Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Calcium			Chromium			Cobalt		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
Black material	J1C2J8	11/2/2010	4250		14.5	4.0	J	0.060	2.8		0.10
Duplicate of J1C2J8	J1C2K0	11/2/2010	3680		14.9	5.3	J	0.061	2.9		0.11

Analysis:

TDL		100	1	2
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)	Yes (continue)
	Both >5xTDL?	Yes (calc RPD)	No-Stop (acceptable)	No-Stop (acceptable)
	RPD	14.4%		
	Difference > 2 TDL?	Not applicable	No - acceptable	No - acceptable

600-315 Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Copper			Iron			Lead		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
Black material	J1C2J8	11/2/2010	6.6		0.22	6470		3.9	4.6		0.28
Duplicate of J1C2J8	J1C2K0	11/2/2010	6.3		0.23	7480		4.0	7.4		0.29

Analysis:

TDL		1	5	5
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)	Yes (continue)
	Both >5xTDL?	Yes (calc RPD)	Yes (calc RPD)	No-Stop (acceptable)
	RPD	4.7%	14.5%	
	Difference > 2 TDL?	Not applicable	Not applicable	No - acceptable

600-315 Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Magnesium			Manganese			Mercury		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
Black material	J1C2J8	11/2/2010	1280	L	3.8	126	J	0.10	0.017	B	0.0058
Duplicate of J1C2J8	J1C2K0	11/2/2010	1360	L	3.9	130	J	0.11	0.016	B	0.0057

Analysis:

TDL		75	5	0.2
Duplicate Analysis	Both > PQL?	Yes (continue)	Yes (continue)	Yes (continue)
	Both >5xTDL?	Yes (calc RPD)	Yes (calc RPD)	No-Stop (acceptable)
	RPD	6.1%	3.1%	
	Difference > 2 TDL?	Not applicable	Not applicable	No - acceptable

Note: Gray cells

B = estimated result. Result is less than the RL but greater than the MDL.
J = estimated result.
HEIS = Hanford Environmental Information System
L = serial dilution, physical and chemical interferences are present
N = Recovery exceeds upper and lower control limits
PQL = practical quantitation limit.
Q = qualifier.
RPD = relative percent difference.
TDL = target detection limit
X = more that 40% defference between columns, lower result reported

Washington Closure Hanford, Inc. CALCULATION SHEET

Originator:	I. B. Berezovskiy	Date:	2/14/2011	Calc. No.:	0600X-CA-V0106	Rev.:	0
Project:	100-IU-6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	2/14/2011
Subject:	600-315 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 600-315 Waste Site. (2 Pages)

600-315 Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Molybdenum			Nickel			Potassium		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
Black material	J1C2J8	11/2/2010	0.39	B	0.27	4.9		0.13	2040		42.1
Duplicate of J1C2J8	J1C2K0	11/2/2010	0.41	B	0.28	4.0	B	0.13	1750		43.4

Analysis:

TDL		2	4	400
Duplicate Analysis	Both > PQL?	**Yes (continue)**	**Yes (continue)**	**Yes (continue)**
	Both >5xTDL?	No-Stop (acceptable)	No-Stop (acceptable)	No-Stop (acceptable)
	RPD			
	Difference > 2 TDL?	No - acceptable	No - acceptable	No - acceptable

600-315 Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Selenium			Silicon			Sodium		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
Black material	J1C2J8	11/2/2010	1.2		0.88	233	J	2.0	77.1	B	60.6
Duplicate of J1C2J8	J1C2K0	11/2/2010	1.4		0.91	205	J	2.2	76.8	B	62.4

Analysis:

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

600-315 Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Vanadium			Zinc			TPH - diesel range		
			mg/kg	Q	PQL	mg/kg	Q	PQL	mg/kg	Q	PQL
Black material	J1C2J8	11/2/2010	13.2		0.10	18.7	JL	0.41	22		0.73
Duplicate of J1C2J8	J1C2K0	11/2/2010	15.1		0.10	19.2	JL	0.42	66		0.74

Analysis:

TDL		2.5	1	5
Duplicate Analysis	Both > PQL?	**Yes (continue)**	**Yes (continue)**	**Yes (continue)**
	Both >5xTDL?	**Yes (calc RPD)**	**Yes (calc RPD)**	No-Stop (acceptable)
	RPD	13.4%	2.6%	2.4%
	Difference > 2 TDL?	Not applicable	Not applicable	Yes - assess further

600-315 Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	TPH - diesel range - extended			Acenaphthylene			Phenanthrene		
			mg/kg	Q	PQL	ug/kg	Q	PQL	ug/kg	Q	PQL
Black material	J1C2J8	11/2/2010	37	N	1.1	48	JX	48	60	J	13
Duplicate of J1C2J8	J1C2K0	11/2/2010	110		1.1	33	JX	33	67		13

Analysis:

TDL		5	15	15
Duplicate Analysis	Both > PQL?	**Yes (continue)**	No-Stop (acceptable)	**Yes (continue)**
	Both >5xTDL?	**Yes (calc RPD)**		No-Stop (acceptable)
	RPD	2.4%		
	Difference > 2 TDL?	Not applicable	No - acceptable	No - acceptable

CONCLUSION:

The calculations in Tables 1 and 2 demonstrate that the 600-315 waste site meets the requirements for the hazard quotients and carcinogenic (excess cancer) risk and RPDs, respectively, as identified in the

Washington Closure Hanford, Inc. CALCULATION SHEET

Originator:	I. B. Berezovskiy	Date:	2/14/2011	Calc. No.:	0600X-CA-V0106	Rev.:	0
Project:	100-IU-6 Field Remediation	Job No:	14655	Checked:	T. E. Queen	Date:	2/14/2011
Subject:	600-315 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations					Sheet No. 7 of 7	

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. 600-315 Confirmatory Sample Results (3 pages).

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
Black material	J1C2J8	11/2/2010	2020		1.6	0.39	UJ	0.39	1.8		0.68	90.1		0.078	0.46		0.034
Duplicate of J1C2J8	J1C2K0	11/2/2010	2140		1.6	0.40	UJ	0.40	2.0		0.70	78.5		0.080	0.34		0.035
Soil under black material	J1C2J9	11/2/2010	3060		1.7	0.41	UJ	0.41	1.8		0.71	71.9		0.082	0.29		0.036
Equipment blank	J1C2J7	11/2/2010	146		1.4	0.35	UJ	0.35	0.61	U	0.61	2.2		0.070	0.030	U	0.030

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
Black material	J1C2J8	11/2/2010	13.3		1.0	0.64		0.042	4250		14.5	4.0	J	0.060	2.8		0.10
Duplicate of J1C2J8	J1C2K0	11/2/2010	10.0		1.0	0.37		0.043	3680		14.9	5.3	J	0.061	2.9		0.11
Soil under black material	J1C2J9	11/2/2010	7.7		1.1	0.33	M	0.044	4260		15.2	4.3	MJ	0.062	3.5		0.11
Equipment blank	J1C2J7	11/2/2010	0.90	U	0.90	0.038	U	0.038	45.3	B	12.9	0.053	UJ	0.053	0.092	U	0.092

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
Black material	J1C2J8	11/2/2010	6.6		0.22	6470		3.9	4.6		0.28	1280	L	3.8	126	J	0.10
Duplicate of J1C2J8	J1C2K0	11/2/2010	6.3		0.23	7480		4.0	7.4		0.29	1360	L	3.9	130	J	0.11
Soil under black material	J1C2J9	11/2/2010	7.9		0.23	8980		4.1	5.6		0.29	1990	L	4.0	169	J	0.11
Equipment blank	J1C2J7	11/2/2010	0.20	U	0.20	198		3.5	0.47		0.25	21.2	L	3.4	4.5	J	0.092

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
Black material	J1C2J8	11/2/2010	0.017	B	0.0058	0.39	B	0.27	4.9		0.13	2040		42.1	1.2		0.88
Duplicate of J1C2J8	J1C2K0	11/2/2010	0.016	B	0.0057	0.41	B	0.28	4.0	B	0.13	1750		43.4	1.4		0.91
Soil under black material	J1C2J9	11/2/2010	0.017	B	0.0060	0.30	B	0.28	4.9		0.13	1630		44.2	0.93	U	0.93
Equipment blank	J1C2J7	11/2/2010	0.0050	U	0.0050	0.24	U	0.24	0.11	U	0.11	53.5	B	37.6	0.79	U	0.79

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
Black material	J1C2J8	11/2/2010	233	J	2.0	0.16	U	0.16	77.1	B	60.6	13.2		0.096	18.7	JL	0.41
Duplicate of J1C2J8	J1C2K0	11/2/2010	205	J	2.2	0.17	U	0.17	76.8	B	62.4	15.1		0.099	19.2	JL	0.42
Soil under black material	J1C2J9	11/2/2010	218	J	2.3	0.17	U	0.17	113	B	63.6	17.6		0.10	24.2	JL	0.43
Equipment blank	J1C2J7	11/2/2010	132	J	1.9	0.15	U	0.15	54.1	U	54.1	0.24	B	0.086	1.1	LJCU	0.37

Note: Gray cells indicate not applicable.

B = estimated result; result is less than the RL but greater than the MDL

C = analyte detected in sample and the QC blanck, and the sample concentration was <= 5X the blank concentration.

HEIS = Hanford Environmental Information System

J = estimated reuslt

L = serial dilution, physical and chemical interferences are present

M = sample duplicate precision not met

N = Recovery exceeds upper and lower control limits

PQL = practical quantitation limit

Q = qualifier

U = undetected

X = more than 40% difference between columns, lower result reported

Attachment	1	Sheet No.	1 of 3
Originator	I. B. Berezovskiy	Date	2/14/11
Checked	T. E. Queen	Date	2/14/11
Calc. No.	0600X-CA-V0106	Rev. No.	0

Attachment 1. 600-315 Waste Site Confirmatory Sample Results (3 pages).

Sample Location	HEIS Number	Sample Date	TPH - diesel range			TPH - diesel range - extended		
			ug/kg	Q	PQL	ug/kg	Q	PQL
Black material	J1C2J8	11/2/2010	22000		730	37000	N	1100
Duplicate of J1C2J8	J1C2K0	11/2/2010	66000		740	110000		1100
Soil under black material	J1C2J9	11/2/2010	64000		750	110000		1100
Equipment blank	J1C2J7	11/2/2010						

Attachment	1	Sheet No.	2 of 3
Originator	I. B. Bereznovskiy	Date	2/14/11
Checked	T. E. Queen	Date	2/14/11
Calc. No.	0600X-CA-V0106	Rev. No.	0

Attachment 1. 600-315 Confirmatory Sample Results (3 pages).

CONSTITUENT	J1C2J8			J1C2K0			J1C2J9			J1C2J7		
	11/2/2010			11/2/2010			11/2/2010			11/2/2010		
	Black material			Duplicate of J1C2J8			Soil under black material			Equipment blank		
	ug/kg	Q	PQL	ug/kg	Q	PQL	ug/kg	Q	PQL	ug/kg	Q	PQL
Polycyclic Aromatic Hydrocarbons (PAHs)												
Acenaphthene	11	U	11	11	U	11	10	U	10			
Acenaphthylene	48	JX	9.8	33	JX	9.8	9.3	U	9.3			
Anthracene	3.3	U	3.3	3.3	U	3.3	3.2	U	3.2			
Benzo(a)anthracene	3.5	U	3.5	3.5	U	3.5	3.3	U	3.3			
Benzo(a)pyrene	7.0	U	7.0	7.0	U	7.0	6.6	U	6.6			
Benzo(b)fluoranthene	4.6	U	4.6	4.6	U	4.6	4.4	U	4.4			
Benzo(ghi)perylene	7.8	U	7.8	7.9	U	7.9	7.5	U	7.5			
Benzo(k)fluoranthene	4.3	U	4.3	4.3	U	4.3	4.1	U	4.1			
Chrysene	5.3	U	5.3	5.3	U	5.3	5.0	U	5.0			
Dibenz[a,h]anthracene	12	U	12	12	U	12	11	U	11			
Fluoranthene	14	U	14	14	U	14	13	U	13			
Fluorene	5.7	U	5.7	5.8	U	5.8	5.5	U	5.5			
Indeno(1,2,3-cd)pyrene	13	U	13	13	U	13	12	U	12			
Naphthalene	13	U	13	13	U	13	12	U	12			
Phenanthrene	60	J	13	67		13	12	U	12			
Pyrene	13	U	13	13	U	13	12	U	12			
Polychlorinated Byphenyls (PCBs)												
Aroclor-1016	3.0	U	3.0	2.9	U	2.9	3.0	U	3.0			
Aroclor-1221	8.6	U	8.6	8.4	U	8.4	8.7	U	8.7			
Aroclor-1232	2.1	U	2.1	2.1	U	2.1	2.2	U	2.2			
Aroclor-1242	5.0	U	5.0	4.9	U	4.9	5.0	U	5.0			
Aroclor-1248	5.0	U	5.0	4.9	U	4.9	5.0	U	5.0			
Aroclor-1254	2.8	U	2.8	2.7	U	2.7	2.8	U	2.8			
Aroclor-1260	2.8	U	2.8	2.7	U	2.7	2.8	U	2.8			

Attachment	1	Sheet No.	3 of 3
Originator	I. B. Berezovskiy	Date	2/14/11
Checked	T. E. Queen	Date	2/14/11
Calc. No.	0600X-CA-V0106	Rev. No.	0

APPENDIX B

SITE-SPECIFIC RESRAD CALCULATION FOR SELENIUM

CALCULATION COVER SHEET

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

Area: 100-IU-6

Discipline: Environmental *Calculation No: 0600X-CA-V0112

Subject: 600-315 Site-Specific Risk Assessment for Selenium

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 - 20 pg Attm. 2 - 10 pg Total – 36 pages	S. W. Clark	M. W. Perrott	I. B. Berezovskiy	D. F. Obenauer	2/28/11

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 SWC	Date:	2/22/11	Calc. No.:	0600X-CA-V0112	Rev.:	0
Project:	100-IU-2/6 Field Remediation	Job No:	14655	Checked:	M. W. Perrott MWP	Date:	2/22/11
Subject:	600-315 Site-Specific Risk Assessment for Selenium					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 600-315 confirmatory sampling site.

GIVEN/REFERENCES:

1) A focused surface sample and duplicate were collected from a black granular stain at the 600-315 waste site (HEIS # J1C2J8 & J1C2K0). Selenium analyses of both samples exceeded the soil cleanup level for protection of the Columbia River (1 mg/kg). The maximum of the two selenium analyses (1.4 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) to predict the selenium concentrations in groundwater. The focused samples represent a site 4 m (13 ft) in diameter having an area of 12.6 m^2 (135.6 ft^2). Dilution and attenuation of selenium concentrations in groundwater as it flows from the area of the 600-315 waste site to the Columbia River was calculated using the U.S. Environmental Protection Agency (EPA) *Soil Screening Guidance: User's Guide.*
2) Selenium data from the focused sampling area (HEIS # J1C2J8 & J1C2K0) were obtained from the *600-315 Relative Percent Difference (RPD) and Direct Contact Hazard Quotient and Carcinogenic Risk Calculations*, Calc. No. 0600X-CA-V0106, 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 600-315, Black Granular Stain*, Work Instruction No. 0600X-WI-G0026, 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

Washington Closure Hanford CALCULATION SHEET

Originator:	S. W. Clark SWC	Date:	2/22/11	Calc. No.:	0600X-CA-V0112	Rev.:	0
Project:	100-IU-2/6 Field Remediation	Job No:	14655	Checked:	M. W. Perrott MWP	Date:	2/22/11
Subject:	600-315 Site-Specific Risk Assessment for Selenium					Sheet No. 2 of 5	

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 600-315 waste site focused sample location (HEIS # J1C2J8 & J1C2K0) in a black granular stain 4 m (13 ft) in diameter having an area of 12.6 m^2 (135.6 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	1.4
Selenium Kd Value	mL/g	5
Contaminated Zone Dimensions		
Cover Depth	m	0
Area of Contaminated Zone (CZ)	m^2	12.6
Length Parallel to Aquifer Flow	m	4
Thickness of Vadose Zone Horizons		
Thickness: Contaminated Zone	m	1.0
Thickness: Unsaturated Zone	m	9.1
Distance from the Waste Site to the Columbia River		
Saturated Zone Groundwater Flow Distance	m	1,750

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 375.

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 600-315 waste site confirmatory focused sampling activities using the uranium-238 isotope as a surrogate for selenium. RESRAD numerical output reports of

Washington Closure Hanford CALCULATION SHEET

Originator:	S. W. Clark	Date:	2/22/11	Calc. No.:	0600X-CA-V0112	Rev.:	0
Project:	100-IU-2/6 Field Remediation	Job No:	14655	Checked:	M. W. Perrott	Date:	2/22/11
Subject:	600-315 Site-Specific Risk Assessment for Selenium					Sheet No. 3 of 5	

selenium concentrations in soil and groundwater are presented in the Attachments to this calculation summary.

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	1750	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	194	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	1750	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) =				194	m		
27	Dilution Factor (D) =				10.6			

RESULTS:

1) Groundwater Protection

Predicted selenium concentrations in groundwater at different time intervals up to 1,000 years were calculated by the RESRAD model using uranium-238 as a 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:	2/22/11	Calc. No.:	0600X-CA-V0112	Rev.:	0
Project:	100-IU-2/6 Field Remediation	Job No:	14655	Checked:	M. W. Perrott	Date:	2/22/11
Subject:	600-315 Site-Specific Risk Assessment for Selenium					Sheet No. 4 of 5	

to reach groundwater within the 1,000 years of the RESRAD model evaluation and to peak at year 375 at a maximum groundwater concentration of 18.45 ug/L. The result 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 600-315

Contaminant	RESRAD Run	Groundwater Concentrations in ug/L at Each Time Interval (yr)								RAG, ug/L
		0	1	10	30	100	300	375	1000	
Selenium	600-315	0	0	0	0	0	0	18.45	0.042	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 600-315 waste site in Table 3 by the dilution factor of 10.6 determined in Table 2. Results are summarized in Table 4. Due to dilution and attenuation, selenium is predicted to reach the river at year 375 with a maximum concentration of 1.7 ug/L, which is less than the 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 600-315

Contaminant	RESRAD Run	Groundwater Concentrations in ug/L at Each Time Interval (yr)								RAG, ug/L
		0	1	10	30	100	300	375	1000	
Selenium	600-315	0	0	0	0	0	0	1.7	0.004	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 600-315 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 from the EPA *Soil Screening Guidance: User's Guide*.

- Selenium concentrations in groundwater are predicted to peak at year 375 at a maximum concentration of 18.45 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:	2/22/11	Calc. No.:	0600X-CA-V0112	Rev.:	0
Project:	100-IU-2/6 Field Remediation	Job No:	14655	Checked:	M. W. Perrott	Date:	2/22/11
Subject:	600-315 Site-Specific Risk Assessment for Selenium					Sheet No. 5 of 5	

- Selenium is predicted to reach the river at a maximum concentration of 1.7 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: 600-315 Selenium Groundwater and River Protection – Mixture Sums and Single Radionuclide Guidelines (20 pages)
2. RESRAD Output: 600-315 Selenium Groundwater and River Protection – Concentration of Radionuclides, (10 pages)

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page   1
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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 = 3.000E+02 16
Time = 3.750E+02 17
Time = 1.000E+03 18
Dose/Source Ratios Summed Over All Pathways 19
Single Radionuclide Soil Guidelines 19
Dose Per Nuclide Summed Over All Pathways 20
Soil Concentration Per Nuclide 20

Attachment 1 Sheet No. 1 of 20
Originator: S. W. Clark Date 2/22/2011
Chk'd By M. W. Perrott Date 2/22/2011
Calc. No. 0600X-CA-V0112 Rev. No. 0

ATTACHMENT 1

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 09:09 Page 2
Summary : 600-315 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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	2.55DE-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 20
Originator: S. W. Clark Date 2/22/2011
Chk'd By M. W. Perrott Date 2/22/2011
Calc. No. 0600X-CA-V0112 Rev. No. 0

ATTACHMENT 1

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 09:09 Page 3
Summary : 600-315 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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 20
Originator: S. W. Clark	Date 2/22/2011
Chk'd By M. W. Perrott	Date 2/22/2011
Calc. No. 0600X-CA-V0112	Rev. No. 0

ATTACHMENT 1

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 09:09 Page 4
Summary : 600-315 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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	---	THICK0
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)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	3.750E+02	1.000E+03	---	T(8)
R011	Times for calculations (yr)	1.000E+03	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	1.400E+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	---	COVER0
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 20
Originator: S. W. Clark Date 2/22/2011
Chk'd By M. W. Perrott Date 2/22/2011
Calc. No. 0600X-CA-V0112 Rev. No. 0

ATTACHMENT 1

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 09:09 Page 5
Summary : 600-315 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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)	9.100E+00	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 20
Originator: S. W. Clark Date 2/22/2011
Chk'd By M. W. Perrott Date 2/22/2011
Calc. No. 0600X-CA-V0112 Rev. No. 0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page   6
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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 20
Originator: S. W. Clark Date 2/22/2011
Chk'd By M. W. Perrott Date 2/22/2011
Calc. No. 0600X-CA-V0112 Rev. No. 0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T½ Limit = 180 days       02/16/2011  09:09  Page   7
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_SELENIUM.RAD
```

Site-Specific Parameter Summary (continued)

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 20
Originator: S. W. Clark Date 2/22/2011
Chk'd By M. W. Perrott Date 2/22/2011
Calc. No. 0600X-CA-V0112 Rev. No. 0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page   8
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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 20
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5     T« Limit = 180 days      02/16/2011  09:09  Page   9
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_SELENIUM.RAD

     Contaminated Zone Dimensions           Initial Soil Concentrations, pCi/g
     ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ           ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
       Area:    900.00 square meters              U-238      1.400E+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)
                        ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
    t (years):  0.000E+00  1.000E+00  3.000E+00  1.000E+01  3.000E+01  1.000E+02  3.000E+02  3.750E+02  1.000E+03
     TDOSE(t):  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  3.618E+00  8.311E-03
         M(t):  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  2.412E-01  5.540E-04
0Maximum TDOSE(t):  3.618E+00 mrem/yr    at t =   375.0 ñ 0.8 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 = 3.750E+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
 ııııııı ııııııııı ıııııı  ııııııııı ıııııı  ııııııııı ıııııı  ııııııııı ıııııı  ııııııııı ıııııı  ııııııııı ıııııı  ııııııııı ıııııı
 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 = 3.750E+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   3.618E+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  3.618E+00 1.0000
 ııııııı ııııııııı ıııııı  ııııııııı ıııııı  ııııııııı ıııııı  ııııııııı ıııııı  ııııııııı ıııııı  ııııııııı ıııııı  ııııııııı ıııııı
 Total   3.618E+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  3.618E+00 1.0000
0*Sum of all water independent and dependent pathways.
```

Attachment 1	Sheet No. 9 of 20
Originator: S. W. Clark	Date 2/22/2011
Chk'd By M. W. Perrott	Date 2/22/2011
Calc. No. 0600X-CA-V0112	Rev. No. 0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page  10
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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

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.
ÄÄÄÄÄÄ	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
ßßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß
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

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.
ÄÄÄÄÄÄ	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
ßßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß	ßßßßßßßßß	ßßßßßß
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.	10 of 20
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page  11
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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- Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil 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- Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* 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 20
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page  12
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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

0*Sum of all water independent and dependent pathways.

Attachment	1	Sheet No.	12 of 20
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  09:09  Page  13
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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 20
Originator: S. W. Clark Date 2/22/2011
Chk'd By M. W. Perrott Date 2/22/2011
Calc. No. 0600X-CA-V0112 Rev. No. 0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page  14
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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

0*Sum of all water independent and dependent pathways.

Attachment	1	Sheet No.	14 of 20
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days      02/16/2011  09:09  Page  15
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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
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+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	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.	15 of 20
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page  16
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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+02 years
Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil 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+02 years
Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* 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.	16 of 20
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  09:09  Page  17
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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 = 3.750E+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 = 3.750E+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	3.618E+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	3.618E+00	1.0000
Total	3.618E+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	3.618E+00	1.0000

0*Sum of all water independent and dependent pathways.

Attachment	1	Sheet No.	17 of 20
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page  18
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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	8.311E-03	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	8.311E-03	1.0000
Total	8.311E-03	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	8.311E-03	1.0000

*Sum of all water independent and dependent pathways.

Attachment	1	Sheet No.	18 of 20
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  09:09  Page  19
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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 3.000E+02 3.750E+02 1.000E+03
 ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ
 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 0.000E+00 1.324E-04 2.990E-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 0.000E+00 2.584E+00 5.834E-03
 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 0.000E+00 1.045E-05 1.010E-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 0.000E+00 8.257E-12 8.112E-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 0.000E+00 1.455E-08 2.337E-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 0.000E+00 5.613E-08 8.273E-07
 U-238+D    äDSR(j)               0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 2.584E+00 5.936E-03
 ßßßßßßßßßß ßßßßßßßßßß ßßßßßßßßß 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   3.000E+02   3.750E+02   1.000E+03
 ÄÄÄÄÄÄ      ÄÄÄÄÄÄÄÄÄÄ  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  *3.361E+05  5.804E+00  2.527E+03
 ßßßßßßß     ßßßßßßßßß  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 =   375.0 ñ 0.8 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 ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ
 U-238   1.400E+00    375.0 ñ 0.8    2.584E+00 5.804E+00 2.584E+00 5.804E+00
 ßßßßßßß ßßßßßßßßßß ßßßßßßßßßßßßßßßß ßßßßßßßßßß ßßßßßßßßßß ßßßßßßßßßß ßßßßßßßßßß
```

Attachment	1	Sheet No. 19 of 20	
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 1

```
1RESRAD, Version 6.5       T« Limit = 180 days        02/16/2011  09:09  Page  20
 Summary : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_SELENIUM.RAD
```

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

ONuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	3.750E+02	1.000E+03
ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	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	0.000E+00	1.854E-04	4.186E-07
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	0.000E+00	3.618E+00	8.167E-03
U-238	äDOSE(j)		0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.618E+00	8.168E-03
0U-234	U-238	9.999E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.463E-05	1.415E-04
0Th-230	U-238	9.999E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.156E-11	1.136E-09
0Ra-226	U-238	9.999E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.037E-08	3.272E-07
0Pb-210	U-238	9.999E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.859E-08	1.158E-06
ßßßßßßß	ßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

ONuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	3.750E+02	1.000E+03
ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ
U-238	U-238	5.400E-05	7.560E-05	7.487E-05	7.342E-05	6.857E-05	5.642E-05	2.850E-05	4.052E-06	1.950E-06	4.390E-09
U-238	U-238	9.999E-01	1.400E+00	1.386E+00	1.360E+00	1.270E+00	1.045E+00	5.278E-01	7.504E-02	3.611E-02	8.130E-05
U-238	äS(j):		1.400E+00	1.386E+00	1.360E+00	1.270E+00	1.045E+00	5.279E-01	7.504E-02	3.611E-02	8.130E-05
0U-234	U-238	9.999E-01	0.000E+00	3.947E-06	1.172E-05	3.762E-05	1.016E-04	2.393E-04	3.116E-04	3.000E-04	1.668E-04
0Th-230	U-238	9.999E-01	0.000E+00	1.780E-11	1.590E-10	1.724E-09	1.447E-08	1.277E-07	6.610E-07	8.673E-07	2.151E-06
0Ra-226	U-238	9.999E-01	0.000E+00	2.572E-15	6.903E-14	2.504E-12	6.378E-11	1.944E-09	3.215E-08	5.336E-08	3.448E-07
0Pb-210	U-238	9.999E-01	0.000E+00	1.987E-17	1.582E-15	1.840E-13	1.264E-11	9.320E-10	2.481E-08	4.356E-08	3.227E-07
ßßßßßßß	ßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß	ßßßßßßßß

THF(i) is the thread fraction of the parent nuclide.

```
0RESCALC.EXE execution time =    3.60 seconds
```

Attachment	1	Sheet No.	20 of 20
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 2

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page   1
 Concent : 600-315 Selenium Groundwater and Columbia River Protection
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_SELENIUM.RAD

                    Table of Contents
                    ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
          Part IV: Concentration of Radionuclides
          ÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ

 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= 3.000E+02 ..................................   8
      Time= 3.750E+02 ..................................   9
      Time= 1.000E+03 ..................................  10
```

Attachment	2	Sheet No. 1 of 10	
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 2

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page   2
 Concent  : 600-315 Selenium Groundwater and Columbia River Protection
 File     : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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	1.400E+00	1.400E+00	1.368E-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	3.501E+00	3.504E+00	3.504E+00	3.504E+00	3.190E-01	5.356E-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 10
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 2

```
1RESRAD, Version 6.5      T« Limit = 180 days        02/16/2011  09:09  Page   3
 Concent  : 600-315 Selenium Groundwater and Columbia River Protection
 File     : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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	1.987E-17	1.987E-17	1.941E-22	0.000E+00	0.000E+00
Ra-226	2.572E-15	2.572E-15	2.513E-20	0.000E+00	0.000E+00
Th-230	1.780E-11	1.780E-11	1.739E-16	0.000E+00	0.000E+00
U-234	3.947E-06	3.947E-06	3.856E-11	0.000E+00	0.000E+00
U-238	1.386E+00	1.386E+00	1.354E-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	2.793E-16	2.054E-16	3.108E-16	3.801E-16	3.181E-17	9.656E-18	0.000E+00	0.000E+00
Ra-226	0.000E+00	9.188E-14	1.021E-13	5.810E-14	6.972E-14	5.064E-15	5.110E-15	0.000E+00	0.000E+00
Th-230	0.000E+00	1.982E-11	1.799E-11	2.176E-11	2.390E-11	1.375E-12	8.800E-14	0.000E+00	0.000E+00
U-234	0.000E+00	9.871E-06	9.879E-06	9.343E-06	9.855E-06	8.996E-07	1.510E-06	0.000E+00	0.000E+00
U-238	0.000E+00	3.468E+00	3.470E+00	3.476E+00	3.474E+00	3.162E-01	5.306E-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 10	
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 2

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 09:09 Page 4
Concent : 600-315 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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	1.582E-15	1.582E-15	1.545E-20	0.000E+00	0.000E+00
Ra-226	6.903E-14	6.903E-14	6.744E-19	0.000E+00	0.000E+00
Th-230	1.590E-10	1.590E-10	1.554E-15	0.000E+00	0.000E+00
U-234	1.172E-05	1.172E-05	1.145E-10	0.000E+00	0.000E+00
U-238	1.360E+00	1.360E+00	1.328E-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	1.818E-14	1.600E-14	2.117E-14	2.259E-14	2.059E-15	6.235E-16	0.000E+00	0.000E+00
Ra-226	0.000E+00	2.660E-12	2.754E-12	2.308E-12	2.437E-12	1.898E-13	1.685E-13	0.000E+00	0.000E+00
Th-230	0.000E+00	1.652E-10	1.599E-10	1.725E-10	1.783E-10	1.014E-11	5.564E-13	0.000E+00	0.000E+00
U-234	0.000E+00	2.930E-05	2.932E-05	2.880E-05	2.930E-05	2.670E-06	4.483E-06	0.000E+00	0.000E+00
U-238	0.000E+00	3.401E+00	3.403E+00	3.409E+00	3.407E+00	3.101E-01	5.203E-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 10
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 2

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 09:09 Page 5
Concent : 600-315 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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	1.840E-13	1.840E-13	1.797E-18	0.000E+00	0.000E+00
Ra-226	2.504E-12	2.504E-12	2.446E-17	0.000E+00	0.000E+00
Th-230	1.724E-09	1.724E-09	1.684E-14	0.000E+00	0.000E+00
U-234	3.762E-05	3.762E-05	3.675E-10	0.000E+00	0.000E+00
U-238	1.270E+00	1.270E+00	1.241E-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	1.928E-12	1.847E-12	2.072E-12	2.113E-12	1.975E-13	6.299E-14	0.000E+00	0.000E+00
Ra-226	0.000E+00	9.906E-11	1.001E-10	9.506E-11	9.656E-11	7.698E-12	6.562E-12	0.000E+00	0.000E+00
Th-230	0.000E+00	1.744E-09	1.730E-09	1.772E-09	1.790E-09	1.015E-10	5.154E-12	0.000E+00	0.000E+00
U-234	0.000E+00	9.408E-05	9.415E-05	9.368E-05	9.415E-05	8.573E-06	1.439E-05	0.000E+00	0.000E+00
U-238	0.000E+00	3.177E+00	3.178E+00	3.184E+00	3.182E+00	2.896E-01	4.860E-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 10
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 2

```
1RESRAD, Version 6.5      T« Limit = 180 days       02/16/2011  09:09  Page   6
Concent : 600-315 Selenium Groundwater and Columbia River Protection
File    : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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	1.264E-11	1.264E-11	1.235E-16	0.000E+00	0.000E+00
Ra-226	6.378E-11	6.378E-11	6.231E-16	0.000E+00	0.000E+00
Th-230	1.447E-08	1.447E-08	1.413E-13	0.000E+00	0.000E+00
U-234	1.016E-04	1.016E-04	9.927E-10	0.000E+00	0.000E+00
U-238	1.045E+00	1.045E+00	1.021E-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	1.286E-10	1.266E-10	1.327E-10	1.336E-10	1.256E-11	4.113E-12	0.000E+00	0.000E+00
Ra-226	0.000E+00	2.542E-09	2.551E-09	2.508E-09	2.521E-09	2.023E-10	1.705E-10	0.000E+00	0.000E+00
Th-230	0.000E+00	1.453E-08	1.451E-08	1.463E-08	1.467E-08	8.317E-10	4.115E-11	0.000E+00	0.000E+00
U-234	0.000E+00	2.541E-04	2.543E-04	2.540E-04	2.543E-04	2.316E-05	3.888E-05	0.000E+00	0.000E+00
U-238	0.000E+00	2.614E+00	2.615E+00	2.620E+00	2.618E+00	2.383E-01	3.999E-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 10
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	Rev. No.	0

ATTACHMENT 2

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 09:09 Page 7
Concent : 600-315 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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	9.320E-10	9.320E-10	9.105E-15	0.000E+00	0.000E+00
Ra-226	1.944E-09	1.944E-09	1.899E-14	0.000E+00	0.000E+00
Th-230	1.277E-07	1.277E-07	1.247E-12	0.000E+00	0.000E+00
U-234	2.393E-04	2.393E-04	2.338E-09	0.000E+00	0.000E+00
U-238	5.279E-01	5.279E-01	5.157E-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	9.390E-09	9.328E-09	9.528E-09	9.545E-09	8.996E-10	2.977E-10	0.000E+00	0.000E+00
Ra-226	0.000E+00	7.767E-08	7.775E-08	7.738E-08	7.749E-08	6.232E-09	5.234E-09	0.000E+00	0.000E+00
Th-230	0.000E+00	1.279E-07	1.280E-07	1.283E-07	1.284E-07	7.277E-09	3.568E-10	0.000E+00	0.000E+00
U-234	0.000E+00	5.984E-04	5.988E-04	5.988E-04	5.990E-04	5.453E-05	9.155E-05	0.000E+00	0.000E+00
U-238	0.000E+00	1.320E+00	1.321E+00	1.323E+00	1.323E+00	1.204E-01	2.020E-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 10
Originator: S. W. Clark Date 2/22/2011
Chk'd By M. W. Perrott Date 2/22/2011
Calc. No. 0600X-CA-V0112 Rev. No. 0

ATTACHMENT 2

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 09:09 Page 8
Concent : 600-315 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_SELENIUM.RAD

Concentration of radionuclides in environmental media
at t = 3.000E+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	2.481E-08	2.481E-08	2.424E-13	0.000E+00	0.000E+00
Ra-226	3.215E-08	3.215E-08	3.141E-13	0.000E+00	0.000E+00
Th-230	6.610E-07	6.610E-07	6.458E-12	0.000E+00	0.000E+00
U-234	3.116E-04	3.116E-04	3.044E-09	0.000E+00	0.000E+00
U-238	7.504E-02	7.504E-02	7.331E-07	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+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	2.493E-07	2.483E-07	2.518E-07	2.519E-07	2.375E-08	7.884E-09	0.000E+00	0.000E+00
Ra-226	0.000E+00	1.285E-06	1.286E-06	1.284E-06	1.285E-06	1.034E-07	8.673E-08	0.000E+00	0.000E+00
Th-230	0.000E+00	6.615E-07	6.627E-07	6.632E-07	6.634E-07	3.759E-08	1.838E-09	0.000E+00	0.000E+00
U-234	0.000E+00	7.792E-04	7.798E-04	7.800E-04	7.800E-04	7.101E-05	1.192E-04	0.000E+00	0.000E+00
U-238	0.000E+00	1.877E-01	1.878E-01	1.881E-01	1.881E-01	1.711E-02	2.872E-02	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. 8 of 10
Originator: S. W. Clark Date 2/22/2011
Chk'd By M. W. Perrott Date 2/22/2011
Calc. No. 0600X-CA-V0112 Rev. No. 0

ATTACHMENT 2

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 09:09 Page 9
Concent : 600-315 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_SELENIUM.RAD

Concentration of radionuclides in environmental media
at t = 3.750E+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	4.356E-08	4.356E-08	4.255E-13	1.523E-08	1.818E-10
Ra-226	5.336E-08	5.336E-08	5.213E-13	2.174E-08	2.595E-10
Th-230	8.673E-07	8.673E-07	8.473E-12	2.794E-11	3.335E-13
U-234	3.000E-04	3.000E-04	2.930E-09	7.070E-05	8.438E-07
U-238	3.611E-02	3.611E-02	3.528E-07	1.845E+01	2.202E-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 = 3.750E+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	1.480E-08	4.502E-07	5.263E-07	5.198E-07	5.221E-07	4.627E-08	1.585E-08	4.401E-08	1.470E-08
Ra-226	2.112E-08	2.152E-06	2.264E-06	2.244E-06	2.247E-06	1.799E-07	1.536E-07	1.048E-08	5.239E-08
Th-230	2.890E-11	8.680E-07	8.697E-07	8.708E-07	8.710E-07	4.932E-08	2.411E-09	2.844E-11	1.436E-10
U-234	7.082E-05	8.454E-04	1.197E-03	1.276E-03	1.278E-03	8.220E-05	1.390E-04	8.546E-06	5.127E-05
U-238	1.844E+01	2.427E+01	1.161E+02	1.263E+02	1.266E+02	3.240E+00	5.959E+00	2.200E+00	1.320E+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 10
Originator: S. W. Clark Date 2/22/2011
Chk'd By M. W. Perrott Date 2/22/2011
Calc. No. 0600X-CA-V0112 Rev. No. 0

ATTACHMENT 2

1RESRAD, Version 6.5 T« Limit = 180 days 02/16/2011 09:09 Page 10
Concent : 600-315 Selenium Groundwater and Columbia River Protection
File : C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\600-315_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	3.227E-07	3.227E-07	3.153E-12	2.180E-07	2.603E-09
Ra-226	3.448E-07	3.448E-07	3.369E-12	3.394E-07	4.051E-09
Th-230	2.151E-06	2.151E-06	2.101E-11	2.822E-09	3.369E-11
U-234	1.668E-04	1.668E-04	1.630E-09	6.847E-04	8.173E-06
U-238	8.130E-05	8.130E-05	7.943E-10	4.164E-02	4.970E-04

*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	2.181E-07	3.527E-06	4.602E-06	4.773E-06	4.774E-06	3.990E-07	1.377E-07	7.804E-07	2.607E-07
Ra-226	3.394E-07	1.424E-05	1.594E-05	1.613E-05	1.613E-05	1.286E-06	1.114E-06	2.025E-07	1.013E-06
Th-230	2.839E-09	2.156E-06	2.174E-06	2.182E-06	2.182E-06	1.225E-07	5.986E-09	3.382E-09	1.693E-08
U-234	6.847E-04	1.316E-03	4.726E-03	5.138E-03	5.138E-03	1.588E-04	2.853E-04	8.173E-05	4.904E-04
U-238	4.164E-02	5.489E-02	2.622E-01	2.877E-01	2.876E-01	7.374E-03	1.351E-02	4.971E-03	2.982E-02

*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.	10 of 10
Originator:	S. W. Clark	Date	2/22/2011
Chk'd By	M. W. Perrott	Date	2/22/2011
Calc. No.	0600X-CA-V0112	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 (WCH 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 logbook (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).

Confirmatory sample data collected at the 600-315 waste site were provided by the laboratory in sample delivery group (SDG) J00906. SDG J00906 comprises three samples (J1C2J8, J1C2J9, and J1C2K0). This SDG includes one field duplicate pair (J1C2J8/J1C2K0). These samples were analyzed for inductively couples plasma (ICP) metals, mercury, total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), and polychlorinated biphenyls (PCBs). In addition, one equipment blank (J1C2J7) was collected and analyzed for ICP metals and mercury. SDG J00906 was submitted for third-party validation. No major deficiencies were observed in data set. Minor deficiencies are discussed as follows below. If no comments are made about a specific analysis, it should be assumed that no deficiencies affecting the quality of the data were found.

In the PAH analysis, third-party validation qualified the acenaphthylene and phenanthrene results for sample J1C2J8 as estimated and flagged "J" due to a surrogate recovery above quality control (QC) limits at (141%). Estimated, or "J"-flagged, data are acceptable for decision-making purposes.

In the ICP metals analysis, the zinc result for sample J1C2J7 (the equipment blank) is of similar magnitude as the method blank result. The result for zinc in sample J1C2J7 may be considered estimated due to method blank contamination. The data is useable for decision-making purposes.

In the ICP metals analysis, the matrix spike recoveries were out of project acceptance criteria for aluminum, manganese, and silicon (53%, 139%, and 41%, respectively). All antimony,

manganese, and silicon data were qualified as estimates and flagged "J" by third-party validation. Estimated data are useable for decision-making purposes.

In the ICP metals analysis, all silicon results were qualified as estimates and flagged "J" by third-party validation, due to a laboratory control sample below quality control limits at 56%. Estimated data are useable for decision-making purposes.

In the ICP metals analysis, the chromium results were qualified as estimates and flagged "J" by third-party validation due to a laboratory duplicate relative percent difference (RPD) above the QC limit of 30% at 43%. 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. Field QA/QC samples, listed in the field logbook (WCH 2010a), are the 600-315 primary and duplicate samples (J1C2J8/J1C2K0). The main and QA/QC sample results are presented in Appendix A.

Field duplicate samples are collected to 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 potential concern (COPC). RPDs are not calculated for analytes that are not detected in both the main and duplicate sample at more than five times the target detection limit (TDL). RPDs of analytes detected at low concentrations (less than five times the detection limit) are not considered to be indicative of the analytical system performance. The RPD calculation brief in Appendix A provides details on duplicate pair evaluation and RPD calculation.

No RPDs in the field duplicate sample are above the acceptance criteria (30%). A secondary check of the data variability is used when one or both of the samples being evaluated (main and duplicate) is less than 5 times the TDL, including undetected analytes. In these cases, a control limit of ± 2 times the TDL is used (Appendix A) to indicate that a visual check of the data is required by the reviewer. The TPH-diesel range data required this check. 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 600-315

waste site 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 600-315 waste site concludes that the reviewed data are of the right type, quality, and quantity to support the intended use. 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, *100 Area Confirmatory Sampling*, Logbook EL-1649, pp. 81-82, Washington Closure Hanford, Richland, Washington.

WCH, 2010b, *Work Instruction for Confirmatory Sampling of the 600-315, Black Granular Stain,* 0600X-WI-G0026, Rev. 0, Washington Closure Hanford, Richland, Washington.