Waste Site Reclassification Form

Date Submitted: 9/11/06	Operable Unit(s): 100-FR-1	Control Number: 2006-045
Originator: L. M. Dittmer	Waste Site ID: 100-F-42	Lead Agency: EPA
Phone: 372-9664	Type of Reclassification Action:	
	Rejected ☐ Closed Out ☐ Interim Closed Out ☒ No Action ☐	

This form documents agreement among the parties listed below authorizing classification of the subject unit as rejected, closed out, interim closed out, or no action and authorizing backfill of the site, if appropriate. Final removal from the National Priorities List (NPL) of no action, interim closed-out, or closed-out sites will occur at a future date.

Description of current waste site condition:

The 100-F-42 waste site is the portion of the former emergency overflow spillway for the 1904-F Outfall Structure formerly existing above the ordinary high water mark of the Columbia River. The spillway consisted of a concrete flume designed to discharge effluent from the 107-F Retention Basin in the event that flows could not be completely discharged via the river outfall pipelines. Remedial actions at this site have been performed in accordance with remedial action objectives and goals established by the U.S. Environmental Protection Agency and the U.S. Department of Energy, Richland Operations Office, in concurrence with the Washington State Department of Ecology. The selected remedial action involved (1) excavating the site to the extent required to meet specified soil cleanup levels, (2) disposing of contaminated excavation materials at the Environmental Restoration Disposal Facility in the 200 Area of the Hanford Site, and (3) backfilling the site with clean soil to adjacent grade elevations.

Basis for reclassification:

The 100-F-42 waste site has been remediated to meet the cleanup standards specified in the 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. The results of verification sampling demonstrated 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 showed that residual contaminant concentrations are protective of groundwater and the Columbia River. The results of deep zone verification sampling also show that residual deep zone contaminant concentrations meet the requirements for unrestricted direct exposure; accordingly, no institutional controls are required for deep zone soils. The basis for reclassification is described in detail in the *Remaining Sites Verification Package for the 116-F-8, 1904-F Outfall Structure and the 100-F-42, 1904-F Spillway* (attached to Waste Site Reclassification Form Control No. 2006-038 for the 116-F-8 sites).

D. C. Smith DOE-RL Project Manager	Signature	9/12/06 Date
NA Ecology Project Manager	Signature	Date
R. A. Lobos EPA Project Manager	Signature	9-26-06 Date

REMAINING SITES VERIFICATION PACKAGE FOR THE 116-F-8, 1904-F OUTFALL STRUCTURE AND THE 100-F-42, 1904-F SPILLWAY

Attachment to Waste Site Reclassification Form 2006-038 and 2006-045

RCK
12/2/08

September 2006

REMAINING SITES VERIFICATION PACKAGE FOR THE 116-F-8, 1904-F OUTFALL STRUCTURE AND THE 100-F-42, 1904-F SPILLWAY

EXECUTIVE SUMMARY

This remaining sites verification package documents completion of remedial action for the 116-F-8 and 100-F-42 waste sites, the 1904-F Outfall Structure and its associated emergency overflow spillway. The formatting of this document follows that used for cleanup verification packages for other radioactive liquid effluent waste sites rather than that used for remaining sites for consistency with the verification sampling approach.

These sites are located in the 100-FR-1 Operable Unit in the 100-F Area of the Hanford Site in southeastern Washington State. During the period of operation from 1945 to 1965, the 1904-F Outfall Structure was used to direct cooling water from the 107-F Retention Basin to the 100-F-39 river pipelines for discharge into the main channel of the Columbia River. The site may also have received diverted effluent flows from the 100-F Area Experimental Animal Farm. The emergency overflow spillway was designed to provide a controlled alternative discharge channel in the event that effluent could not be completely discharged via the river pipelines.

Site excavation and waste disposal are complete, and the exposed surfaces have been sampled and analyzed to verify attainment of the remedial action goals. Results of the sampling, laboratory analyses, and data evaluations for the 116-F-8 and 100-F-42 sites indicate that all remedial action objectives for direct exposure, protection of groundwater, and protection of the Columbia River have been met (see Table ES-1).

The sites meet cleanup standards and have been reclassified as interim closed out in accordance with the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) and the Waste Site Reclassification Guideline TPA-MP-14 (RL-TPA-90-0001) (DOE-RL 1998).

Table ES-1. Summary of Cleanup Verification Results for the 116-F-8 and 100-F-42 Waste Sites. (2 Pages)

Regulatory Requirement	Remedial Action Goals	Results	Remedial Action Objectives Attained?	Ref.
Direct Exposure – Radionuclides	1. Attain 15 mrem/yr dose rate above background over 1,000 years.	1. Maximum dose rate based on generic dose-equivalence lookup values is < 2 mrem/yr (Table 3).	Yes	NA
Direct Exposure – Nonradionuclides	1. Attain individual COC RAGs.	1. The residual concentrations for hexavalent chromium (the only nonradionuclide COC) are below the direct exposure RAG.	Yes	a

Table ES-1. Summary of Cleanup Verification Results for the 116-F-8 and 100-F-42 Waste Sites. (2 Pages)

Regulatory Requirement	Remedial Action Goals	Results	Remedial Action Objectives Attained?	Ref.
Nonradionuclide Risk Requirements	1. Attain hazard quotient of <1 for noncarcinogens.	1. The individual hazard quotients for hexavalent chromium (the only nonradionuclide COC) in each decision unit are less than 1.	Yes	a
	2. Attain cumulative hazard quotient of <1 for noncarcinogens.	2. Cumulative hazard quotients for each decision unit are less than 1.		
	3. Attain excess cancer risk of $<1 \times 10^{-6}$ for individual carcinogens.	3. Individual excess carcinogenic risk values for hexavalent chromium (the only nonradionuclide COC) in each decision unit are less than 1×10^{-6}.		
	4. Attain a total excess cancer risk of $<1 \times 10^{-5}$ for carcinogens.	4. Cumulative excess carcinogenic risk values for each decision unit are less than 1×10^{-5}.		
Groundwater/River Protection – Radionuclides	1. Attain single-COC groundwater and river protection RAGs.	1. RESRAD modeling predicts that residual radionuclides will not exceed MCLs.	Yes	NA
	2. Attain National Primary Drinking Water Standards: 4 mrem/yr (beta/gamma) dose rate to target receptor/organs.	2. RESRAD modeling predicts a maximum "all pathways" dose rate of 5.33×10^{-4} mrem/yr.		
	3. Meet drinking water standards for alpha emitters: the more stringent of the 15 pCi/L MCL or 1/25th of the derived concentration guide per DOE Order 5400.5.	3. No alpha-emitting radionuclide COCs were identified.	NA	
	4. Meet total uranium standard of 21.2 pCi/L.[b]	4. Uranium was not identified as a COC.	NA	NA
Groundwater/River Protection – Nonradionuclides	1. Attain individual nonradionuclide groundwater and river cleanup requirements.	1. Residual hexavalent chromium concentrations are below soil RAGs for protection of groundwater and the Columbia River.	Yes	a
Other supporting Information	1. Sample variance calculations (Appendix A)			c
	2. Sample location design (Appendix A)			d

[a] *116-F-8 Waste Site Cleanup Verification 95% UCL Calculations*, Calculation No. 0100F-CA-V0249, Rev. 0, Washington Closure Hanford, Richland, Washington (Appendix A).

[b] Uranium limits selected in 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* (EPA 1999) and *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2005b) were based on 1/25th of the derived concentration guidelines from DOE Order 5400.5. Since the time of Record of Decision signature, the U.S. Environmental Protection Agency has promulgated a more restrictive MCL of 30 µg/L for total uranium (65 *Federal Register* 76708). Based on the isotopic distribution of uranium in the 100 Areas, 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*, 0100X-CA-V0038 (BHI 2001a).

[c] *116-F-8 Outfall Structure Variance Calculation*, Calculation No. 0100F-CA-V0253, Rev. 0, and *116-F-8 Outfall Structure Overburden Variance Calculation*, Calculation No. 0100F-CA-V0254, Rev. 0, Washington Closure Hanford, Richland, Washington.

[d] *116-F-8 Shallow, Deep Zone and Overburden Sampling Plan*, Calculation No. 0100F-CA-V0242, Rev. 0, Washington Closure Hanford, Richland, Washington.

COC = contaminant of concern
NA = not applicable
RAG = remedial action goal
MCL = maximum contaminant level (drinking water standard)
UCL = upper confidence limit

REMAINING SITES VERIFICATION PACKAGE FOR THE 116-F-8, 1904-F OUTFALL STRUCTURE AND THE 100-F-42, 1904-F SPILLWAY

INTRODUCTION

This remaining sites verification package documents that the 116-F-8 and 100-F-42 waste sites were remediated in accordance with 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* (hereafter referred to as the Remaining Sites ROD) (EPA 1999). Remedial action objectives (RAOs) and remedial action goals (RAGs) for these sites are documented in the Remaining Sites ROD (EPA 1999) and the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP) (DOE-RL 2005b). The Remaining Sites ROD provides the U.S. Department of Energy, Richland Operations Office, the authority, guidance, and objectives to conduct this remedial action.

The remedy specified in the Remaining Sites ROD and conducted for the 116-F-8 waste site included (1) excavating the site to the extent required to meet specified soil cleanup levels, (2) disposing of contaminated excavation materials at the Environmental Restoration Disposal Facility (ERDF) in the 200 Area of the Hanford Site, and (3) backfilling the site with clean soil to match adjacent grade elevation. The 100-F-42 waste site was administratively separated from the 116-F-8 waste site for future inclusion within the Remaining Sites ROD by agreement among the Tri-Parties (Hedel 2005). It was subsequently determined that sufficient evidence existed to warrant remedial action at the 100-F-42 waste site during remediation of the 116-F-8 waste site, and both waste sites were remediated and evaluated as a single unit.

Excavation was driven by RAOs for direct exposure, protection of groundwater, and protection of the Columbia River. For the respective points of compliance, RAGs summarized in Table 1 were established for the contaminants of concern (COCs) in the RDR/RAWP (DOE-RL 2005b). The waste site COCs presented in Table 1 were based on the list presented in the Remaining Sites ROD (EPA 1999), as expanded in the *100 Area Remedial Action Sampling and Analysis Plan* (SAP) (DOE-RL 2005a) for the 116-F-8 waste site. Cesium-137 was also included as a COC due to analytical detections within verification samples.

Table 1. 116-F-8 and 100-F-42 Remedial Action Goals. (2 Pages)

COCs	Direct Exposure RAG	Groundwater Protection RAG	Columbia River Protection RAG
Cesium-137	15 mrem/yr (cumulative)[a]	4 mrem/yr (cumulative)[b]	4 mrem/yr (cumulative)[b]
Cobalt-60			
Europium-152			
Europium-154			
Europium-155			

Table 1. 116-F-8 and 100-F-42 Remedial Action Goals. (2 Pages)

COC	Direct Exposure RAG (mg/kg)	Soil RAG for Groundwater Protection (mg/kg)	Soil RAG for Columbia River Protection (mg/kg)
Hexavalent chromium	2.1[c] 240[d]	4.8[e]	2[f]

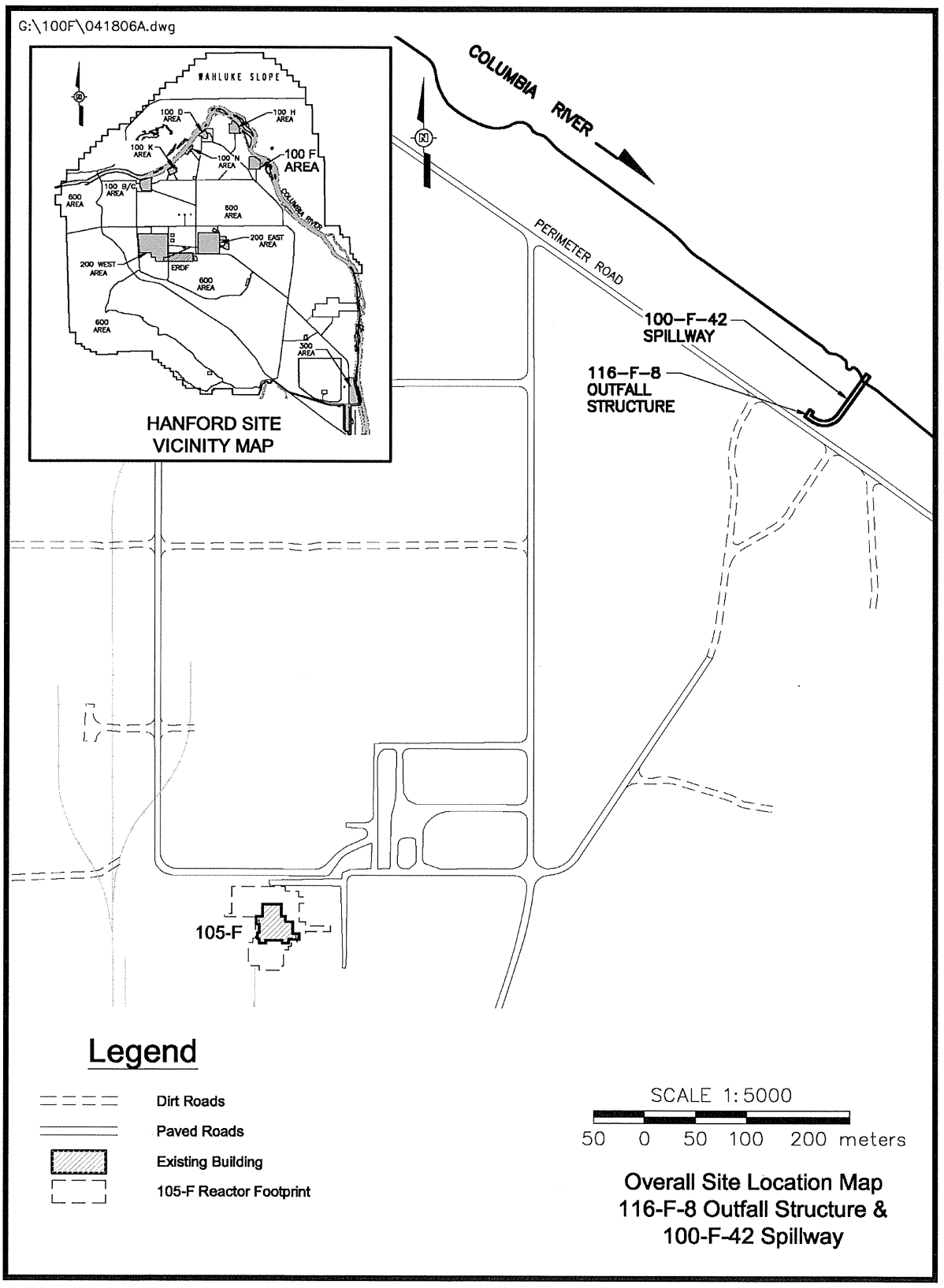
[a] Lookup values that correspond to the 15 mrem/yr dose rate based on a generic site model are presented in the RDR/RAWP (DOE-RL 2005b).
[b] Lookup values that correspond to the individual radionuclide 4 mrem/yr dose rate equivalent for beta- and gamma-emitter RAGs per National Drinking Water Standards are presented in the RDR/RAWP (DOE-RL 2005b).
[c] WAC 173-340-750(3) Method B carcinogenic cleanup limit based on the inhalation exposure pathway, per *Calculation of Hexavalent Chromium Carcinogenic Risk* (BHI 2000).
[d] WAC 173-340-740(3) Method B noncarcinogenic cleanup limit.
[e] Calculated soil RAG per WAC 173-340-720(3), 1996 (Method B for groundwater) and WAC 173-340-740(3)(a)(ii)(A), 1996 ("100 times rule") is lower than that presented in the RDR/RAWP (DOE-RL 2005b), based on the updated oral reference dose value (as provided in IRIS).
[f] Soil RAG based on 100 times dilution attenuation factor times the most restrictive surface water quality standard as presented in the RDR/RAWP (DOE-RL 2005b).
CFR = *Code of Federal Regulations*
COC = contaminant of concern
IRIS = Integrated Risk Information System
MCL = maximum contaminant level (drinking water standard)
RAG = remedial action goal
RDR/RAWP = remedial design report/remedial action work plan
WAC = *Washington Administrative Code*

Soil cleanup levels were established in the Remaining Sites ROD (EPA 1999) based 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 COCs; screening levels were not exceeded. A baseline risk assessment for the river corridor portion of the Hanford Site began in 2004, which includes a more complete quantitative ecological risk assessment. That baseline risk assessment will be used to support the final closeout decisions for the 116-F-8 and 100-F-42 waste sites.

SITE DESCRIPTION AND SUPPORTING INFORMATION

The 116-F-8 waste site is part of the 100-FR-1 Operable Unit in the 100-F Area. The site consists of the former 1904-F Outfall Structure, an open-topped concrete weir box measuring 8.2 m (27 ft) by 4.3 m (14 ft) by 7.9 m (26 ft) deep, with all but the upper 0.3 m (1 ft) existing below grade (DeFord 1993). The site is located approximately 700 m (2,300 ft) northeast of the 105-F Reactor Building, adjacent to the Columbia River (Figure 1).

Figure 1. Hanford Site Map and Location of the 116-F-8 and 100-F-42 Waste Sites.



The outfall structure was designed to channel reactor cooling water effluent from the 107-F Retention Basin (116-F-14 waste site) into two 1.07-m (42-in.) river outfall pipelines (100-F-39 waste site) exiting the northeastern side of the outfall structure. Influent from the 107-F Retention Basin entered the southern side of the 116-F-8 outfall structure via two steel pipelines (100-F-19:1 waste site), with diameters of 1.52 m (60 in.) and 0.91 m (36 in.). The influent pipelines were removed in 2001 as part of previous remedial activities (BHI 2001b). Waste effluent from the 100-F Area Experimental Animal Farm, which was typically discharged to the adjacent 116-F-16 outfall structure, could also be diverted to the 116-F-8 outfall via a distribution box.

The outfall structure was also connected to an emergency overflow spillway (100-F-42), designed to control overflow in the event that flow could not be completely discharged via the outfall pipelines. The overflow spillway consisted of a reinforced concrete flume approximately 4 m (13 ft) wide and 0.6 m (2 ft) deep, and extended from the outfall structure into the Columbia River. The 100-F-42 waste site encompasses the portion of the overflow spillway and associated contaminated soils above the Columbia River ordinary high water mark.

Designed use of the outfall structure coincided with historic operations in the 100-F Area, from 1945 to 1965. The above-grade portion of the structure was demolished into the cavity in 1979, and the site was backfilled and covered with clean soil (WHC 1991).

EXCAVATION AND DISPOSAL

Remedial action activities at the 116-F-8 and 100-F-42 waste sites were conducted from August 31, 2004, to September 22, 2005. Remediation involved excavation and staging of clean overburden material and removal of the demolished concrete outfall structure, the concrete spillway structure above the Columbia River ordinary high water mark, and contaminated soil to the extent required to satisfy the RAOs and corresponding RAGs. The residual 100-F-39 effluent pipelines will be sealed with concrete prior to backfill of the remediation footprint. Contaminated materials were disposed at the ERDF.

Pre- and post-remediation topographic maps are shown in Figures 2 and 3, respectively. Approximately 1,325 m^2 (14,260 ft^2) of plan area was excavated, including excavation within the deep zone (greater than 4.6 m [15 ft] below ground surface) up to 8 m (26 ft) below ground surface. Approximately 4,900 metric tons (5,400 U.S. tons) of material from the sites was removed and disposed at the ERDF.

FIELD SCREENING AND VARIANCE SAMPLING

Radiological field screening was conducted during the site remedial actions as specified in the SAP (DOE-RL 2005a). Field screening was used to guide the excavation to quickly assess the presence and level of contamination. Field screening at the site included using a radiological data mapping system survey, hand-held sodium iodide (NaI) detectors, and gamma energy analyses of grab samples. The hand-held NaI detectors were used to screen excavated waste material and to screen the excavation wall and floor for potential hot spots. Gamma energy

Figure 2. Pre-Remediation Topographic Plan for the 116-F-8 and 100-F-42 Waste Sites.

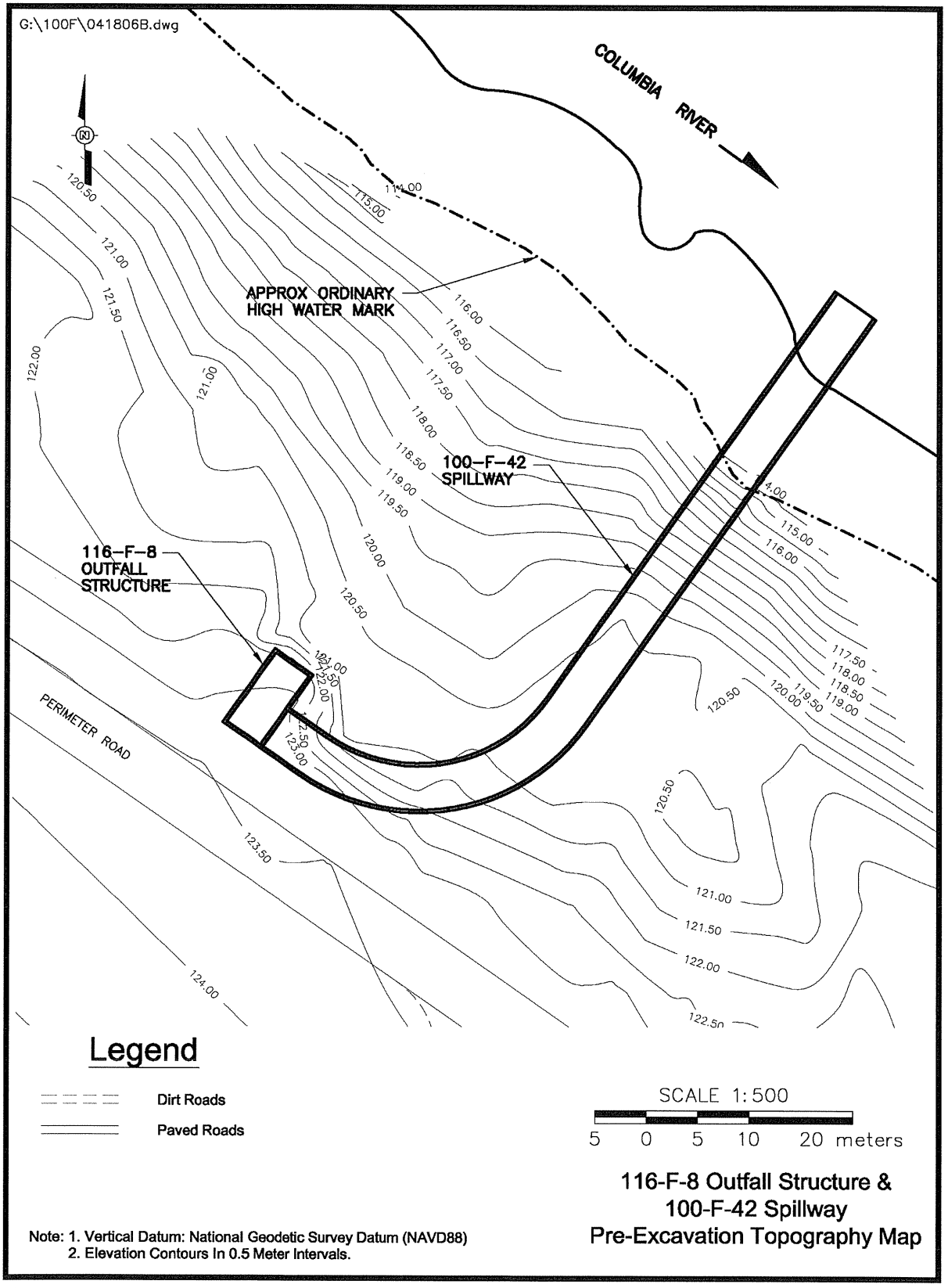
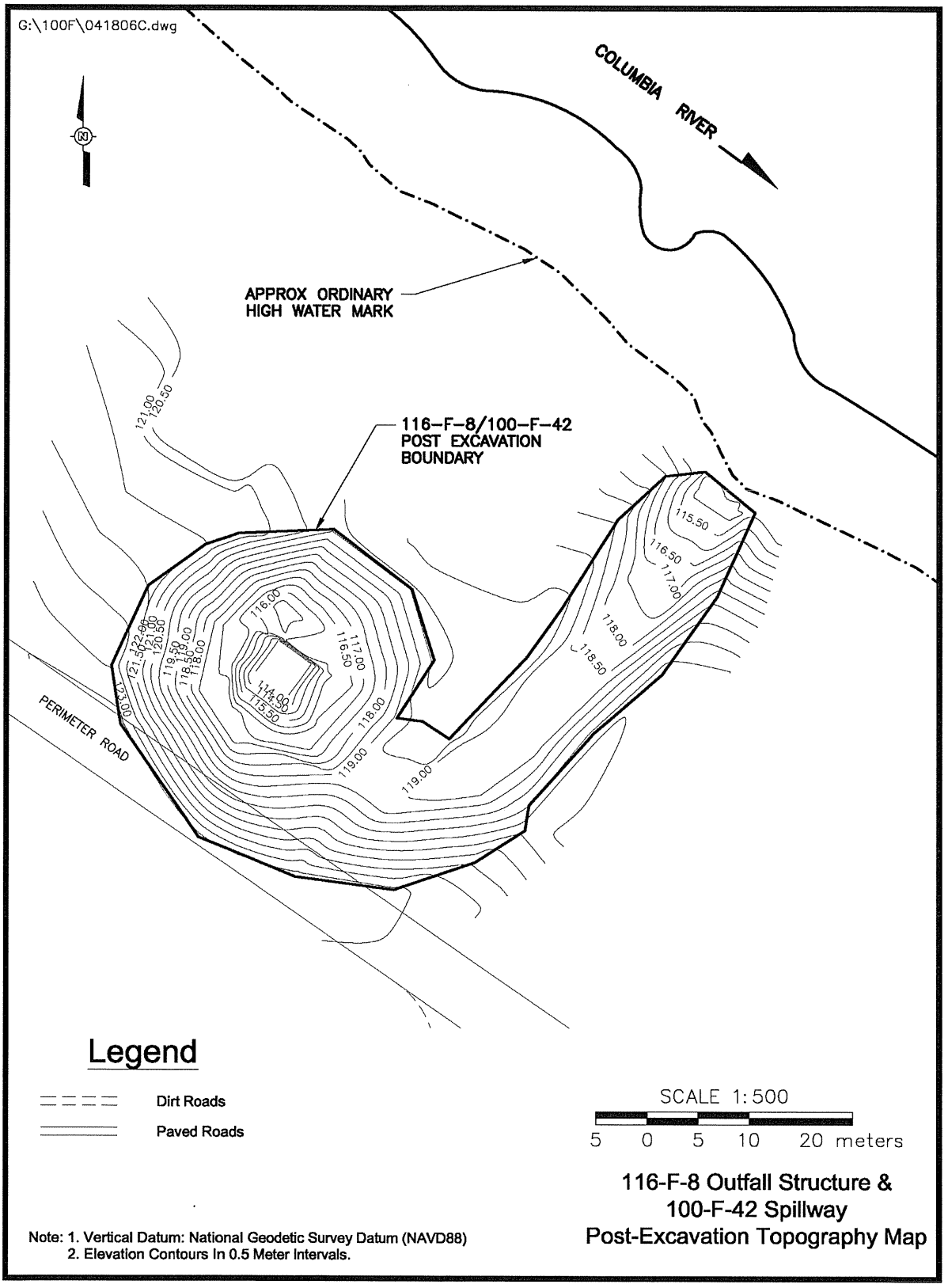


Figure 3. Post-Remediation Topographic Plan for the 116-F-8 and 100-F-42 Waste Sites.



analyses were used to support waste characterization and to corroborate the radiological mapping survey and hand-held NaI detector data. The radiological survey completed in the area of the former outfall structure (Figure 4) indicated an area of residual radiological activity. Additional material was removed from this location, followed by surveys with hand-held instrumentation, which detected no residual radiological activity above background levels. The radiological survey completed in the area of the former spillway showed elevated measurements throughout the area. The character of the data suggested equipment miscalibration or malfunction, and follow-up surveys were performed with hand-held instrumentation over the area (Figure 5). Measurements observed during these surveys were consistent with the measured local background level, with no reading exceeding 5,000 dpm/cm^2.

Variance sampling was performed following an initial determination that remedial action objectives had been achieved. Variance sampling was performed at the overburden and shallow zone decision units on February 1 and 7, 2006, respectively, with 24 variance samples collected from each decision unit to support variance analysis. The variance analysis quantifies the variability of residual contamination (see calculation briefs in Appendix A). This information was used to determine the site-specific number of final cleanup verification samples to be collected. The results of the variance analyses indicated that the number of verification samples to be taken for each shallow zone and overburden decision subunit was less than the default number of four specified in the SAP (DOE-RL 2005a); therefore, four final verification samples were collected from each of the shallow zone and overburden decision subunits. The default number of three verification samples (DOE-RL 2005a) was collected from the deep zone decision subunit.

CLEANUP VERIFICATION SAMPLING AND ANALYSIS

Final cleanup verification sampling was conducted from February 9 to 26, 2006 (WCH 2006a, 2006b), following variance analyses. The final verification samples were submitted to offsite laboratories for analysis using approved U.S. Environmental Protection Agency analytical methods as required per the SAP (DOE-RL 2005a). Each verification sample was composed of a composite sample formed by combining soil collected at the required number of randomly selected locations within each sampling area (excluding the quality assurance/quality control samples).

Due to their immediate proximity and historic functional relationship, the 116-F-8 and 100-F-42 waste sites were combined into one unit for the purposes of decision unit stratification. The division of the combined site excavation into decision units (i.e., shallow zone and deep zone) as shown on the sample design figures (Appendix A) is a function of the applicable RAGs. The direct exposure, groundwater protection, and river protection RAGs are applicable to soils within 4.6 m (15 ft) of the ground surface (i.e., shallow zone and overburden soil). The groundwater protection and river protection RAGs are applicable to soils greater than 4.6 m (15 ft) below the ground surface (i.e., deep zone).

The 116-F-8/100-F-42 waste site combined unit consisted of shallow zone, deep zone, and overburden decision units. The shallow zone consisted of the excavation sidewalls and floors

Figure 4. Radiological Mapping Survey Results for the 116-F-8 Site.

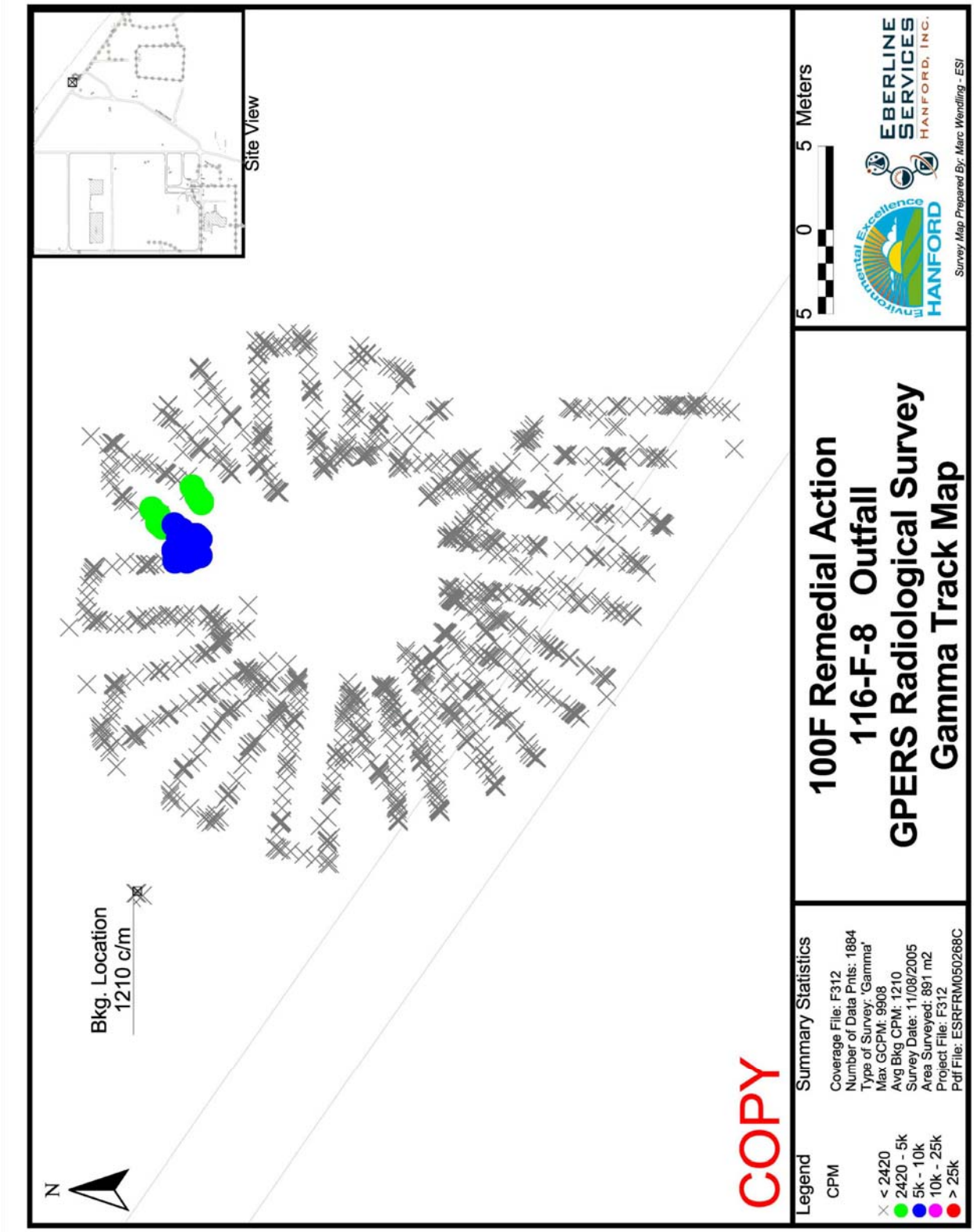
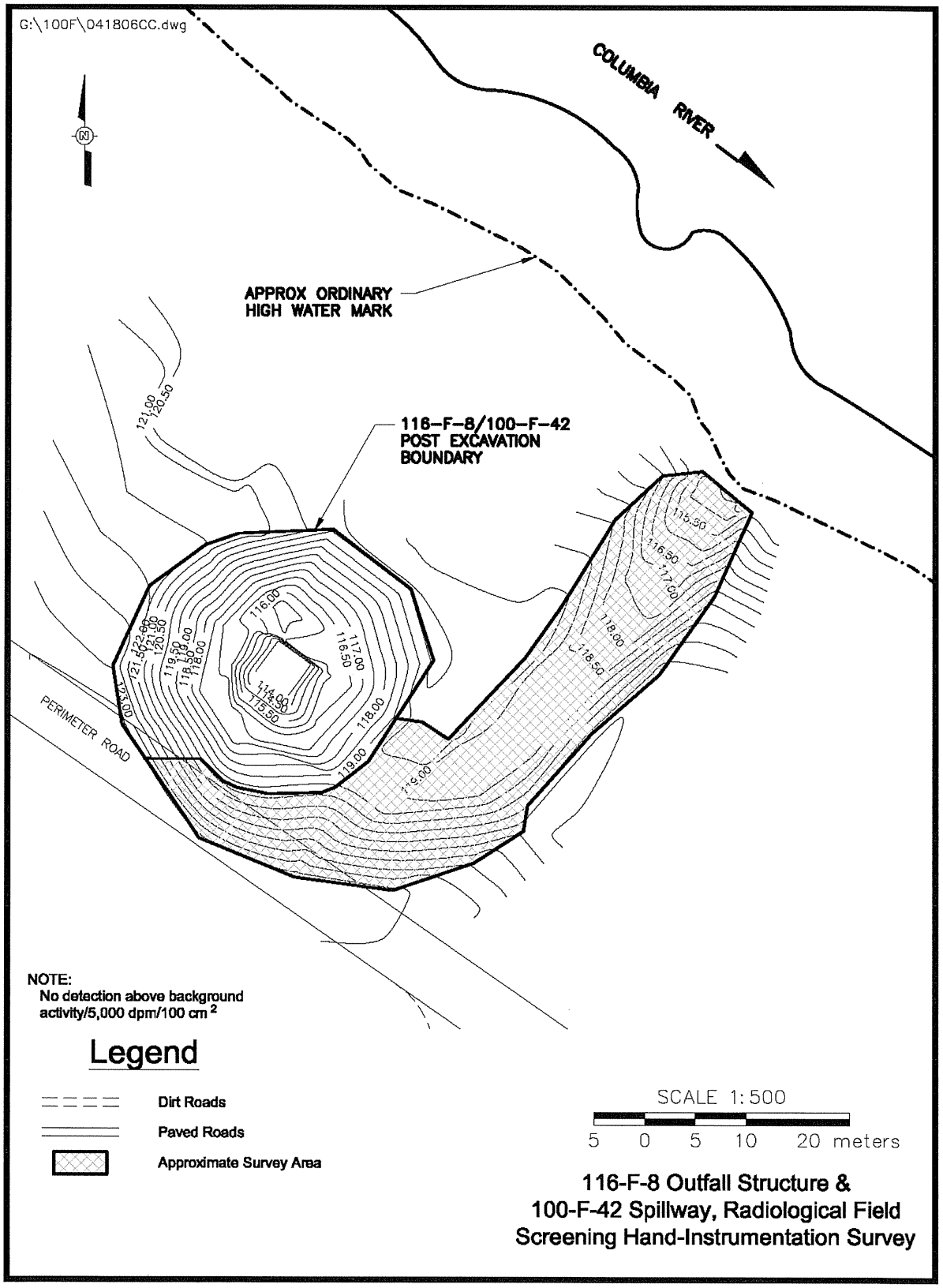


Figure 5. Hand-Held Instrumentation Radiological Survey Area for the 100-F-43 Site.



that were less than 4.6 m (15 ft) below ground surface. The deep zone consisted of the portions of the excavation sidewalls and excavation floor that were more than 4.6 m (15 ft) below ground surface. The shallow zone decision unit contained one decision subunit, divided into four sampling areas. The deep zone decision unit contained one decision subunit, divided into three sampling areas. The overburden decision unit contained one subunit, divided into four sampling areas. All sampling areas were further divided into 16 sampling nodes each as shown in the sample design methodology and sample location figures presented in the calculation briefs in Appendix A.

CLEANUP VERIFICATION DATA EVALUATION

This section presents the evaluation of the 116-F-8/100-F-42 cleanup verification data for comparison with the data quality criteria and RAGs.

Data Quality Assessment Process

A data quality assessment (DQA) is performed to compare the verification sampling approach and resulting analytical data with the sampling and data quality requirements specified by the project objectives and performance specifications.

The DQA for the 116-F-8 and 100-F-42 waste sites determined that the data are of the right type, quality, and quantity to support site verification decisions within specified error tolerances. All analytical data were found to be acceptable for decision-making purposes. The evaluation also verified that the sample design was sufficient to support clean site verification. The cleanup verification sample analytical data are stored in the Environmental Restoration project-specific database prior to archiving in the Hanford Environmental Information System and are included within the 95% upper confidence limit (UCL) calculation brief in Appendix A. The detailed DQA is presented in Appendix B.

Contaminants of Concern 95% Upper Confidence Limit

The primary statistical calculation to support cleanup verification is the 95% UCL on the arithmetic mean of the data. The 95% UCL values for each COC are computed for each decision unit (i.e., shallow zone, deep zone, and overburden). Prior to calculating the 95% UCL, the individual sample results are reviewed and, as appropriate, adjusted per the SAP (DOE-RL 2005a). This process is summarized below.

For radionuclides, the laboratory-reported value is used in the calculation of the 95% UCL. In cases where the laboratory does not report a value for data qualified with a "U" (i.e., less than the detection limit), one-half of the minimum detectable activity is used in the calculation of the 95% UCL. For nonradionuclides, a value equal to one-half the practical quantitation limit is used for data flagged with a "U" (i.e., less than the detection limit) in the calculation of the 95% UCL, as required by *Washington Administrative Code* (WAC) 173-340-740[7][g].

Statistical calculations for verification data sets are presented in the 95% UCL calculation brief (Appendix A), with results shown in Table 2. The columns on the left side of Table 2 are the COCs and the 95% UCL values before subtraction of background. The fifth column of Table 2 presents the background, where values exist, and the last three columns present the statistical values adjusted for background, if appropriate, which becomes the cleanup verification data set used for further evaluation and modeling.

Table 2. 116-F-8 and 100-F-42 Cleanup Verification Data Set.

COCs	95% UCL Statistical Values[a] (pCi/g)			Hanford Site Background[b] (pCi/g)	Cleanup Verification Data Set[c] (pCi/g)		
	Shallow Zone	Deep Zone	Overburden		Shallow Zone	Deep Zone	Overburden
Cesium-137	0.044 (ND)	0.249	0.056 (ND)	1.1	0.044 (ND)	0.249	0 (<BG) (ND)
Cobalt-60	0.047 (ND)	0.081 (ND)	0.057 (ND)	0.008	0.047 (ND)	0.081 (ND)	0.049 (ND)
Europium-152	0.100 (ND)	2.37	0.15 (ND)	NA	0.100 (ND)	2.37	0.15 (ND)
Europium-154	0.14 (ND)	0.22 (ND)	0.18 (ND)	0.033	0.14 (ND)	0.22 (ND)	0.14 (ND)
Europium-155	0.12 (ND)	0.16 (ND)	0.13 (ND)	0.054	0.12 (ND)	0.16 (ND)	0.08 (ND)
COC	**95% UCL Statistical Values[a] (mg/kg)**			**Hanford Site Background (mg/kg)**	**Cleanup Verification Data Set (mg/kg)**		
	Shallow Zone	**Deep Zone**	**Overburden**		**Shallow Zone**	**Deep Zone**	**Overburden**
Hexavalent chromium	0.27	0.22 (ND)	0.22	NA	0.27	0.22 (ND)	0.22

[a] Laboratory data, including the minimum detectable activities for the individual cleanup verification samples, are included in the 95% UCL calculation brief in Appendix A.
[b] Represents the 90th percentile of the lognormal distribution (DOE-RL 1996).
[c] For overburden, anthropogenic background (DOE-RL 1996) and naturally occurring background is subtracted from all radionuclides. For other decision units (i.e., shallow zone and deep zone), only naturally occurring background (uranium) is subtracted. Refer to the 95% UCL calculation brief in Appendix A for additional details on determination of statistical values.
BG = background
COC = contaminant of concern
NA = not applicable
ND = not detected (in all samples in the data set)
UCL = upper confidence limit

Cleanup Verification Model

While the statistical values summarized in Table 2 were significantly below generic dose-equivalence lookup values, a site-specific cleanup verification model was developed using RESidual RADioactivity (RESRAD) version 6.3 for the 116-F-8/100-F-42 waste site combined unit due to the proximity of groundwater and the Columbia River. The model (illustrated in the RESRAD calculation brief provided in Appendix A) assumes that the entire unsaturated deep zone is contaminated at the statistical activity levels presented in Table 2. This assumption is

conservative, because the residual condition at the site is a thin layer of contamination overlain by clean backfill material in the deep zone.

EVALUATION OF REMEDIAL ACTION GOAL ATTAINMENT

Evaluations in the following sections demonstrate that remedial action at the 116-F-8 and 100-F-42 waste sites has achieved the applicable RAGs. The first two sections address attainment of direct exposure RAGs, and the groundwater and Columbia River protection RAGs. The third section documents application of the WAC 173-340-740(7)(e) three-part test, which is required for nonradionuclide COCs only.

DIRECT EXPOSURE SOIL REMEDIAL ACTION GOALS ATTAINED

Radionuclides

Table 3 compares the shallow zone (including overburden) radionuclide cleanup verification statistically quantified values presented in Table 2 to direct exposure single radionuclide 15 mrem/yr dose-equivalence values and shows the sum of fractions evaluations. The columns on the left side of Table 3 are the COCs and the 95% UCL values, corrected for background, as appropriate. The fourth column of Table 3 presents the single radionuclide 15 mrem/yr dose-equivalence activity, and the last two columns present the statistical values divided by the dose-equivalence activity. As demonstrated by the summation of these fractions, the cumulative dose above background contributed by residual radionuclide populations will be significantly less than the 15 mrem/yr RAG.

Table 3. Attainment of Radionuclide Direct Exposure RAG.

COCs	95% UCL Statistical Values (pCi/g)		Activity Equivalent to 15 mrem/yr Dose[a] (pCi/g)	Fraction	
	Shallow Zone	Overburden		Shallow Zone	Overburden
Cesium-137	0.044 (ND)	0 (<BG) (ND)	6.2	0.007	0
Cobalt-60	0.047 (ND)	0.049 (ND)	1.4	0.034	0.035
Europium-152	0.100 (ND)	0.15 (ND)	3.3	0.030	0.045
Europium-154	0.14 (ND)	0.14 (ND)	3	0.047	0.047
Europium-155	0.12 (ND)	0.08 (ND)	125	0.001	0.001
			Sum of Fractions	0.119	0.128
			Equivalent Dose (mrem/yr)	<1.8	<2

[a] Single radionuclide 15 mrem/yr dose-equivalence values and derivation methodology are presented in the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2005b).

BG = background
COC = contaminant of concern
ND = not detected (in all samples in the data set)
UCL = upper confidence limit

Nonradionuclides

Direct Comparison to RAGs. Table 4 compares the shallow zone and overburden nonradionuclide cleanup verification statistical values presented in Table 2 to the direct exposure RAGs presented in Table 1. Residual concentrations of hexavalent chromium, the sole nonradionuclide COC, are less than the direct exposure RAG.

Table 4. Attainment of Nonradionuclide Direct Exposure RAGs.

COC	Direct Exposure RAG (mg/kg)	Cleanup Verification Data Set (mg/kg)	Direct Exposure RAG Attained?[a]
Shallow Zone			
Hexavalent chromium	2.1[b] 240[c]	0.27	Yes
Overburden			
Hexavalent chromium	2.1[b] 240[c]	0.22	Yes

[a] Criterion is comparison to direct exposure RAG.
[b] WAC 173-340-750(3) Method B carcinogenic cleanup limit based on the inhalation exposure pathway, per *Calculation of Hexavalent Chromium Carcinogenic Risk* (BHI 2000).
[c] WAC 173-340-740(3) Method B noncarcinogenic cleanup limit.
COC = contaminant of concern
RAG = remedial action goal
WAC = *Washington Administrative Code*

Noncarcinogenic Hazard Quotient RAG Attained. For noncarcinogenic COCs, WAC 173-340-740(5)(a) and (b) specify the evaluation of the hazard quotient, which is given as daily intake divided by a reference dose (DOE-RL 2005b). This evaluation is shown in the 95% UCL calculation briefs (Appendix A). The calculated hazard quotients for statistical residual hexavalent chromium concentrations (the only nonradionuclide COC) in the shallow zone and overburden decision units are 1.1×10^{-3} and 9.4×10^{-4}, respectively. These values are below the individual and cumulative RAGs (a hazard quotient of <1.0 in both cases).

Carcinogenic Risk RAG Attained. For individual nonradionuclide carcinogenic COCs, the WAC 173-340-700(3) Method B cleanup limits are based on an individual excess cancer risk of 1×10^{-6}. The cumulative excess cancer risk for all nonradionuclide carcinogenic COCs must be less than 1×10^{-5}. The only nonradionuclide COC identified, hexavalent chromium, is a carcinogen in the inhalation exposure pathway. The excess lifetime cancer risk estimate for residual concentrations of this COC in the shallow zone and overburden decision units are 1.3×10^{-7} and 1.1×10^{-7}, respectively. These values are below the risk limit for individual COCs (1×10^{-6}) and the cumulative excess carcinogenic risk RAG of 1×10^{-5}.

GROUNDWATER AND RIVER PROTECTION REMEDIAL ACTION GOALS ATTAINED

Radionuclides

Residual activity levels of cesium-137 and europium-152, the only radionuclide COCs detected in verification samples from the 116-F-8/100-F-42 waste site combined unit, were included in the site-specific RESRAD model (Appendix A). Groundwater and river protection RAGs for radionuclides are both based on achieving maximum contaminant levels (MCLs) for drinking water (DOE-RL 2005b). Because the only pathway for contaminants to reach the river is via groundwater, attainment of groundwater protection RAGs is synonymous to attainment of river protection RAGs.

The site-specific model predicts that the maximum cumulative dose rate is 5.33×10^{-4} mrem/yr, occurring in the year 2049, as compared to the MCL of 4 mrem/yr. This dose assessment is conservative, because it includes pathways that are not part of the conceptual exposure model for deep zone soils under the rural residential scenario (Appendix A). The maximum cesium-137 activity predicted in groundwater at the site is 0.0102 pCi/L, as compared to the MCL of 60 pCi/L (DOE-RL 2005b). Residual europium-152 at the site is not predicted to affect groundwater within 1,000 years. Therefore, all groundwater and river protection RAGs have been attained.

Nonradionuclides

Table 5 compares the shallow zone, deep zone, and overburden nonradionuclide cleanup verification statistical values presented in Table 2 to the soil RAG for groundwater and river protection presented in Table 1. Residual concentrations of hexavalent chromium, the sole nonradionuclide COC, are less than the soil RAG for groundwater and river protection.

WAC 173-340 THREE-PART TEST FOR NONRADIONUCLIDES

The WAC 173-340-740(7)(e) three-part test is required for nonradionuclide statistical verification data sets. The three-part test consists of the following criteria: (1) the cleanup verification statistical value must be less than the most restrictive cleanup level, (2) no single detection within the data set can exceed two times the most restrictive cleanup criteria, and (3) the percentage of samples in the data set exceeding the most restrictive cleanup criteria must be less than 10%.

Table 6 summarizes the results of the WAC 173-340-740[7][e] three-part test for the cleanup verification nonradionuclide data sets in comparison to the most restrictive applicable RAG. The table lists the most restrictive RAG (from Table 1), the statistical value, the maximum detected value, the total number of samples collected, and the percentage of samples exceeding the RAG. The final column of the table describes the result of applying the three criteria using the values listed in the preceding columns. As demonstrated in Table 6, residual concentrations of hexavalent chromium (the sole nonradionuclide COC) in all decision units pass the three-part test in comparison to the most restrictive applicable RAG.

Table 5. Attainment of Nonradionuclide Groundwater and River Protection RAGs.

COC	Cleanup Verification Data Set (mg/kg)	Soil RAG for Groundwater Protection (mg/kg)	Soil RAG for River Protection (mg/kg)	Cleanup Criteria Attained?[a]
Shallow Zone				
Hexavalent chromium	0.27	4.8[b]	2[c]	Yes
Deep Zone				
Hexavalent chromium	0.22 (ND)	4.8[b]	2[c]	Yes
Overburden				
Hexavalent chromium	0.22	4.8[b]	2[c]	Yes

[a] Criterion is comparison to soil RAG for groundwater protection.
[b] Calculated soil RAG per WAC 173-340-720(3), 1996 (Method B for groundwater) and WAC 173-340-740(3)(a)(ii)(A), 1996 ("100 times rule") is lower than that presented in the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2005b), based on the updated oral reference dose value (as provided in IRIS).
[c] Soil RAG based on 100 times dilution attenuation factor times the most restrictive surface water quality standard as presented in the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2005b).
COC = contaminant of concern ND = not detected (in all samples in the data set)
IRIS = Integrated Risk Information System RAG = remedial action goal

Table 6. Application of the WAC 173-340 Three-Part Test. (2 Pages)

COC	Most Restrictive Applicable RAG[a]	Statistical Cleanup Verification Value (mg/kg)[b]	Maximum Detected Cleanup Verification Value (mg/kg)[c]	Total Number of Samples[d]	Percentage of Cleanup Verification Data Set Exceeding RAG[e]	Cleanup Criteria Attained?
Shallow Zone						
Hexavalent chromium	2[f]	0.27	0.35	5	0	Yes
Deep Zone						
Hexavalent chromium	2[f]	0.22 (ND)	ND	4	0	Yes
Overburden						
Hexavalent chromium	2[f]	0.22	0.25	5	0	Yes

[a] From Table 1, the most restrictive RAG for hexavalent chromium is the soil RAG for protection of the Columbia River.
[b] Criterion is statistical value cannot exceed most restrictive applicable RAG.
[c] Criterion is no single detection can exceed two times the most restrictive applicable RAG.
[d] Total number of samples in the decision unit includes field duplicate samples, which are included in the evaluation as separate samples.
[e] Criterion is percentage of data set exceeding the most restrictive applicable RAG cannot exceed 10%.
[f] Soil RAG based on 100 times dilution attenuation factor times the most restrictive surface water quality standard as presented in the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2005b).
COC = contaminant of concern RAG = remedial action goal
ND = not detected (in all samples in the data set) WAC = *Washington Administrative Code*

STATEMENT OF PROTECTIVENESS

This remaining sites verification package demonstrates that remedial action at the 116-F-8 and 100-F-42 waste sites has achieved the RAOs and corresponding RAGs established in the Remaining Sites ROD (EPA 1999) and the RDR/RAWP (DOE-RL 2005b). The contaminated materials from these site have been excavated and disposed at the ERDF. The remaining soils at the sites have been sampled, analyzed, and evaluated, and the results do not preclude any future uses (as bounded by the rural-residential scenario), allow unrestricted use of shallow zone soils, and pose no threat to groundwater or the Columbia River. Residual deep zone contaminant concentrations also meet the requirements for unrestricted direct exposure; accordingly, no institutional controls are required for deep zone soils.

REFERENCES

65 FR 76708, 2000, "National Primary Drinking Water Regulations; Radionuclides; Final Rule," *Federal Register*, Vol. 65, No. 236, p. 76708 (December 7).

ANL, 2005, *RESRAD for Windows*, Version 6.3, Argonne National Laboratory, Environmental Assessment Division, Argonne, Illinois.

BHI, 2000, *Calculation of Hexavalent Chromium Carcinogenic Risk*, 0100X-CA-V0031, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 2001a, *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.

BHI, 2001b, *Cleanup Verification Package for the 100-F-19:1 North Pipelines, 100-F-19:3 West Pipelines, 100-F-34 Biology Facility French Drain, and 116-F-12 French Drain*, CVP-2001-00002, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 2005, *100 Area Analogous Sites RESRAD Calculations*, Calculation No. 0100X-CA-V0050, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

DeFord, D. H., 1993, *100-F Reactor Site Technical Baseline Report Including Operable Units 100-FR-1 and 100-FR-2*, WHC-SD-EN-TI-169, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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

DOE-RL, 1996, *Hanford Site Background: Part 2, Soil Background for Radionuclides*, DOE/RL-96-12, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998, *Tri-Party Agreement Handbook Management Procedures,* RL-TPA-90-0001, Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)," U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2005a, *100 Area Remedial Action Sampling and Analysis Plan*, DOE/RL-96-22, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2005b, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 5, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order,* 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

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.

Hedel, C. W., 2005, *Path Forward for Final Disposition of 100 Area River Effluent Pipelines*, Meeting Minutes, CCN 112483, Bechtel Hanford, Inc., Richland, Washington.

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

WCH, 2006a, *100-F Area RAWD Sampling*, Logbook EFL-1174, Washington Closure Hanford, Richland, Washington.

WCH, 2006b, *100-F Area RAWD Sampling*, Logbook EFL-1174-1, Washington Closure Hanford, Richland, Washington.

WHC, 1991, *Summary of the Hanford Site Decontamination, Decommissioning, and Cleanup FY 1974 Through FY 1990*, WHC-EP-0478, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

CALCULATION BRIEFS

DISCLAIMER FOR CALCULATIONS

The calculations that are provided in the following appendix 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.

CALCULATION BRIEFS

The following calculation briefs have been prepared in accordance with ENG-1, *Engineering Services*, ENG-1-4.5, "Project Calculations," Washington Closure Hanford, Richland, Washington.

116-F-8 Shallow, Deep Zone and Overburden Sampling Plan, Calculation No. 0100F-CA-V0242, Rev. 0, Washington Closure Hanford, Richland, Washington.

116-F-8 Outfall Structure Variance Calculation, Calculation No. 0100F-CA-V0253, Rev. 0, Washington Closure Hanford, Richland, Washington.

116-F-8 Outfall Structure Overburden Variance Calculation, Calculation No. 0100F-CA-V0254, Rev. 0, Washington Closure Hanford, Richland, Washington.

116-F-8 Waste Site Cleanup Verification 95% UCL Calculations, Calculation No. 0100F-CA-V0249, Rev. 0, Washington Closure Hanford, Richland, Washington.

116-F-8 Waste Site Cleanup Verification RESRAD Calculation, Calculation No. 0100F-CA-V0270, Rev. 0, Washington Closure Hanford, Richland, Washington.

NOTE: The calculation briefs referenced in this appendix are kept in the active Washington Closure Hanford project files and are available upon request. When the project is completed, the files will be stored in a U.S. Department of Energy, Richland Operations Office repository. Only excerpts of the calculation briefs are included in this appendix.

CALCULATION COVER SHEET

Project Title:	**116-F-8 Outfall Structure Sample Design**	**Job No.**	**14655**
Area	**100-F**		
Discipline	**Environmental Engineering**	**Calc. No.**	**0100F-CA-V0242**
Subject	**116-F-8 Shallow, Deep Zone and Overburden Sampling Plan**		
Computer Program	**Excel**	**Program No.**	**Excel 2003**

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

Committed Calculation ☒ **Preliminary** ☐ **Superseded** ☐ **Voided** ☐

Rev.	Sheet Numbers	Originator	Checker	Reviewer	Approval	Date
0	Cover = 1 Sht Calc = 2 Shts Attach1 = 1 Sht Attach2 = 1 Sht Attach3 = 3 Shts Total = 8 Shts	G. Cruz 02/06/06	C.A. Bentz 2/6/06	R.T. Coffman 2/9/06	S.W. Callison 2-9-06	2-9-06

SUMMARY OF REVISIONS	

*Obtain Calc. No. from DIS

DE01437.03 (12/09/2004)

Washington Closure Hanford

CALCULATION SHEET

Originator G. Cruz **Date** 2/1/2006 **Calc. No.** 0100F-CA-V0242 **Rev. No.** 0

Project 116-F-8 Outfall Structure Sample Design **Job No.** 14655 **Checked** CAB **Date** 2/6/06

Subject 116-F-8 Shallow, Deep Zone and Overburden Sampling Plan **Sheet No.** 1 of 2

1	**Problem:**	Calculate and display required sampling nodes in concurrence with 100 Area		
2		SAP DOE/RL-96-22 Rev. 3 for verification and closure.		
3				
4	**Given:**	-SAP (DOE/RL-96-22 Rev. 3) and IG (0100X-IG-G0001 Rev. 5) requirements		
5		-Shallow Zone Sampling Area (Surface area of each zone determined from CAD program,		
6		Attachment 3, Sht 1 of 3, CAD file 1F:020106A, 116-F-8 Outfall Structure Shallow Zone Sampling Plan)		
7		-Deep Zone Sampling Area (Surface area of each zone determined from CAD program,		
8		Attachment 3, Sht 2 of 3, CAD file 1F:020106B, 116-F-8 Outfall Structure Deep Zone Sampling Plan)		
9		-Overburden Sampling Area (Surface area of each zone determined from CAD program,		
10		Attachment 3, Sht 3 of 3, CAD file 1F:020106C, 116-F-8 Outfall Structure Overburden Sampling Plan)		
11				
12				
13				
14				
15	**SAP and IG Requirements:**			
16		-Develop a 16 node sampling grid for the sampling area		
17	Shallow Zone	-Use appendix A of the IG to determine which six of the sixteen will be sampled		
18		to collect variance and clean up verification samples		
19				
20		-Develop a 16 node sampling grid for the sampling area		
21	Overburden:	-Use appendix A of the IG to determine which six of the sixteen will be sampled		
22		to collect variance and clean up verification samples		
23				
24		-Develop a 16 node sampling grid for the sampling area		
25	Deep Zone:	-Use appendix A of the IG to determine which four of the sixteen will be sampled		
26		to collect variance/verification samples		
27				
28	**Determination of Shallow Zone Sampling Grid:**			
29				
30	Shallow Zone Sampling Grid Area determined from Table 5-1, IG			
31	Attachment 2, Number of Decision Subunits Based on Area (Converted to Sq Meters)			
32				
33	Total Area:		1094.63	m^2
34	Area of Decision Subunits (total area 1 subunit)		1094.63	m^2
35				
36	Decision Subunit divided into 4 Sampling Areas:		273.65	m^2
37				
38	Sampling Areas divided into a 16 node grid (node numbers 1-16):		17.10	m^2
39				
40	Nodes to be Sampled (as determined from Attachment 1, Table A-1, Sample Grid Point Lookup Table)			
41		See Attachment 3, Sht 1 of 3, 116-F-8 OutFall Structure Shallow Zone Sampling Plan,		
42		for Sample Location Table		
43				
44				
45				
46				

Washington Closure Hanford

CALCULATION SHEET

Originator G. Cruz **Date** 2/1/2006 **Calc. No.** 0100F-CA-V0242 **Rev. No.** 0

Project 116-F-8 Outfall Structure Sample Design **Job No.** 14655 **Checked** CAB **Date** 2/6/06

Subject 116-F-8 Shallow, Deep Zone and Overburden Sampling Plan **Sheet No.** 2 of 2

Determination of Deep Zone Sampling Grid:

Deep Zone Sampling Grid Area determined from Table 5-1, IG
Attachment 2, Number of Decision Subunits Based on Area (Converted to Sq Meters)

Total Area:	230.36	m^2
Area of Decision Subunits (total area 1 subunit)	230.36	m^2
Decision Subunits divided into 3 Sampling Areas:	76.78	m^2
Sampling Areas divided into a 16 node grid (node numbers 1-16):	4.79	m^2

Nodes to be Sampled (as determined from Attachment 1, Table A-1, Sample Grid Point Lookup Table)
See Attachment 3, Sht 2 of 3, 116-F-8 Outfall Structure Deep Zone Sampling Plan, for Sample Location Table

Determination of Overburden Sampling Grid:

Overburden Sampling Grid Area determined from Table 5-1, IG
Attachment 2, Number of Decision Subunits Based on Area (Converted to Sq Meters)

Total Area:	906.90	m^2
Area of Decision Subunits (total area 1 subunit)	906.90	m^2
Decision Subunits divided into 4 Sampling Areas:	226.72	m^2
Sampling Areas divided into a 16 node grid (node numbers 1-16):	14.17	m^2

Nodes to be Sampled (as determined from Attachment 1, Table A-1, Sample Grid Point Lookup Table)
See Attachment 3, Sht 3 of 3, 116-F-8 Outfall Structure Overburden Sampling Plan, for Sample Location Table

Washington Closure Hanford

Originator	G. Cruz	Date	2/1/2006	Calc. No.	0100F-CA-V0242	Rev. No.	0
Project	116-F-8 Outfall Structure Sample Design	Job No.	14655	Checked	GJB	Date	2/6/06
Subject	116-F-8 Shallow, Deep Zone and Overburden Sampling Plan			Sheet No	1 of 1		

ATTACHMENT 1

Sample Grid Point Lookup Table.

Default Plan	Sampling Area 1	Sampling Area 2	Sampling Area 3	Sampling Area 4	Sampling Area 5	Sampling Area 6	Sampling Area 7	Sampling Area 8	Sampling Area 9	Sampling Area 10
Variance/Verification	3	6	1	4	5	1	3	3	4	16
Variance/Verification	4	7	11	3	15	15	5	13	10	10
Variance/Verification	16	3	2	7	7	10	11	4	3	14
Variance/Verification	10	15	4	12	1	13	4	8	16	4
Variance	2	14	5	9	13	12	8	2	14	8
Variance	13	10	9	13	2	16	1	12	5	3
Not Sampling	6	1	10	8	14	4	16	5	8	6
Not Sampling	1	9	13	1	10	5	12	1	1	15
Not Sampling	9	12	7	5	6	2	6	7	15	9
Not Sampling	15	16	15	14	16	6	2	15	11	1
Not Sampling	8	13	8	10	12	11	13	14	2	12
Not Sampling	5	2	3	11	4	3	9	10	7	11
Not Sampling	7	11	14	15	11	14	14	6	13	2
Not Sampling	11	4	6	2	9	7	7	11	9	7
Not Sampling	12	8	16	16	3	8	15	9	6	13
Not Sampling	14	5	12	6	8	9	10	16	12	5

** **Note:** Grid nodes for each sampling area in each waste site should be numbered consistently, e.g., begin numbering the nodes in the northwestern-most node, then number consecutively left to right.

Washington Closure Hanford

Originator G. Cruz Date 2/1/2006 Calc. No. 0100F-CA-V0242 Rev. No. 0

Project 116-F-8 Outfall Structure Sample Design Job No. 14655 Checked Date

Subject 116-F-8 Shallow, Deep Zone and Overburden Sampling Plan Sheet No. 1 of 1

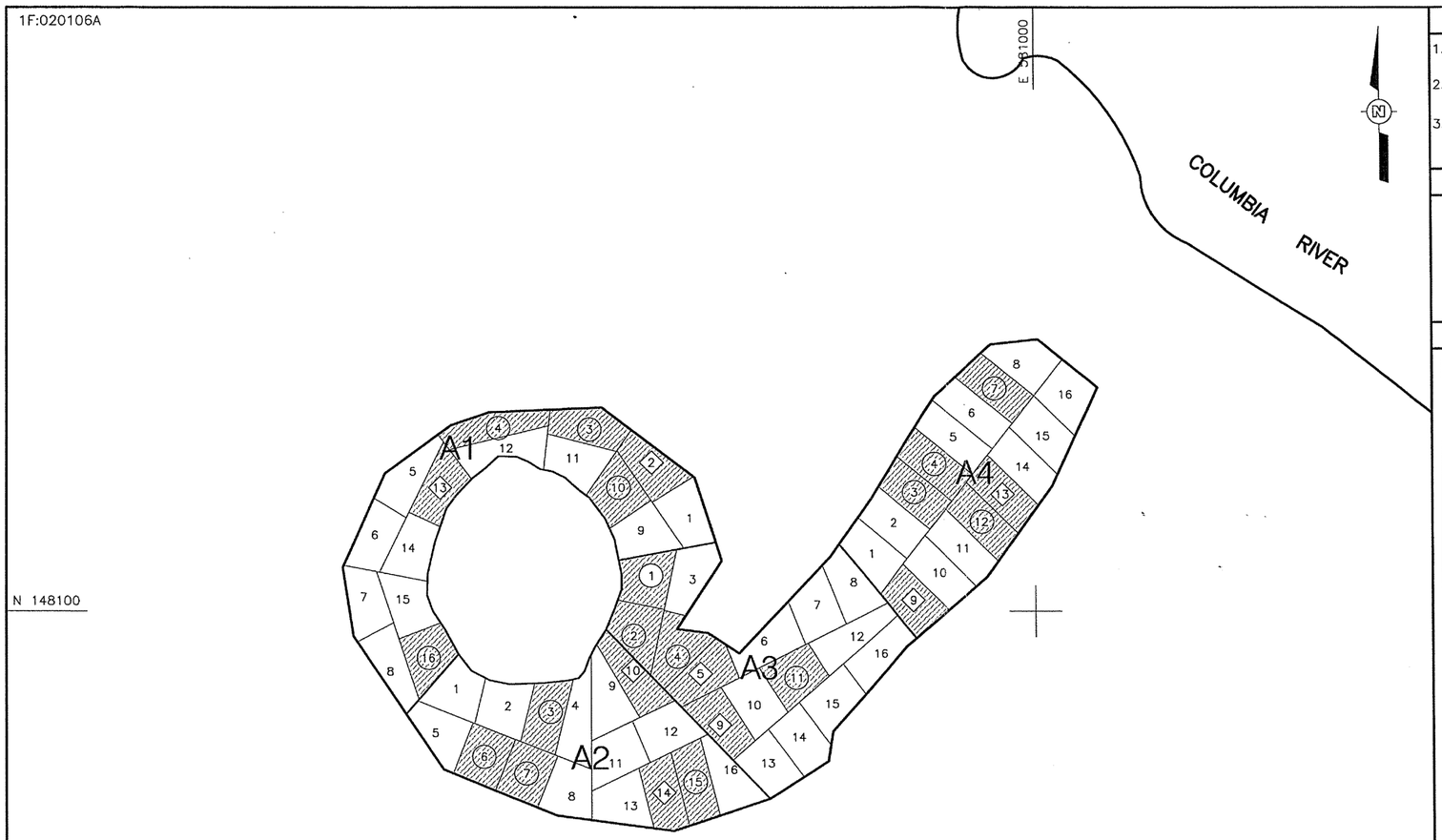
ATTACHMENT 2

Number of Decision Subunits Based on Area.

Area of Primary Decision Unit (m2)	Number of Subunits
<1,394	1
>1,394 to <2,326	2
>2,326 to <3,256	3
>3,256 to <4,186	4
>4,186 to <9,303	2
>9,303 to <13,024	3
>13,024 to <16,745	4
>16,745 to <20,466	5
>20,466	ROUND[a] (Area/3,720)

[a] ROUND is an integer rounding function.

1F:020106A



SCALE 1:400

4 0 4 8 16 meters

NOTES

1. SHALLOW ZONE NODE AREAS ARE APPROXIMATELY 17.10 SQUARE METERS.
2. SAMPLES ARE TAKEN FROM THE APPROXIMATE CENTER OF EACH NODE.
3. THE SHALLOW ZONE CONSISTS OF SAMPLING AREAS A1, A2, A3, AND A4 WITHIN DECISION SUBUNIT 1.

LEGEND

(8) VARIANCE AND VERIFICATION SAMPLING NODE

(8) VERIFICATION SAMPLING NODE

SAMPLE LOCATION TABLE

DECISION SUBUNIT	SAMPLING AREA	SAMPLE NODE	NORTHING	EASTING
1	A1	S-A1-2	148112.42	580968.20
		S-A1-3	148115.18	580963.11
		S-A1-4	148115.30	580955.64
		S-A1-10	148110.32	580965.49
		S-A1-13	148110.30	580950.80
		S-A1-16	148096.11	580949.80
	A2	S-A2-3	148091.62	580959.85
		S-A2-6	148087.87	580954.41
		S-A2-7	148086.46	580957.87
		S-A2-10	148095.06	580966.65
		S-A2-14	148084.86	580969.15
		S-A2-15	148085.75	580971.72
	A3	S-A3-1	148102.97	580968.14
		S-A3-2	148097.95	580966.71
		S-A3-4	148096.21	580970.29
		S-A3-5	148094.79	580972.15
		S-A3-9	148090.52	580973.73
		S-A3-11	148094.46	580980.08
	A4	S-A4-3	148109.92	580989.97
		S-A4-4	148112.31	580991.62
		S-A4-7	148118.63	580996.64
		S-A4-9	148100.93	580989.88
		S-A4-12	148107.46	580995.57
		S-A4-13	148109.76	580997.26

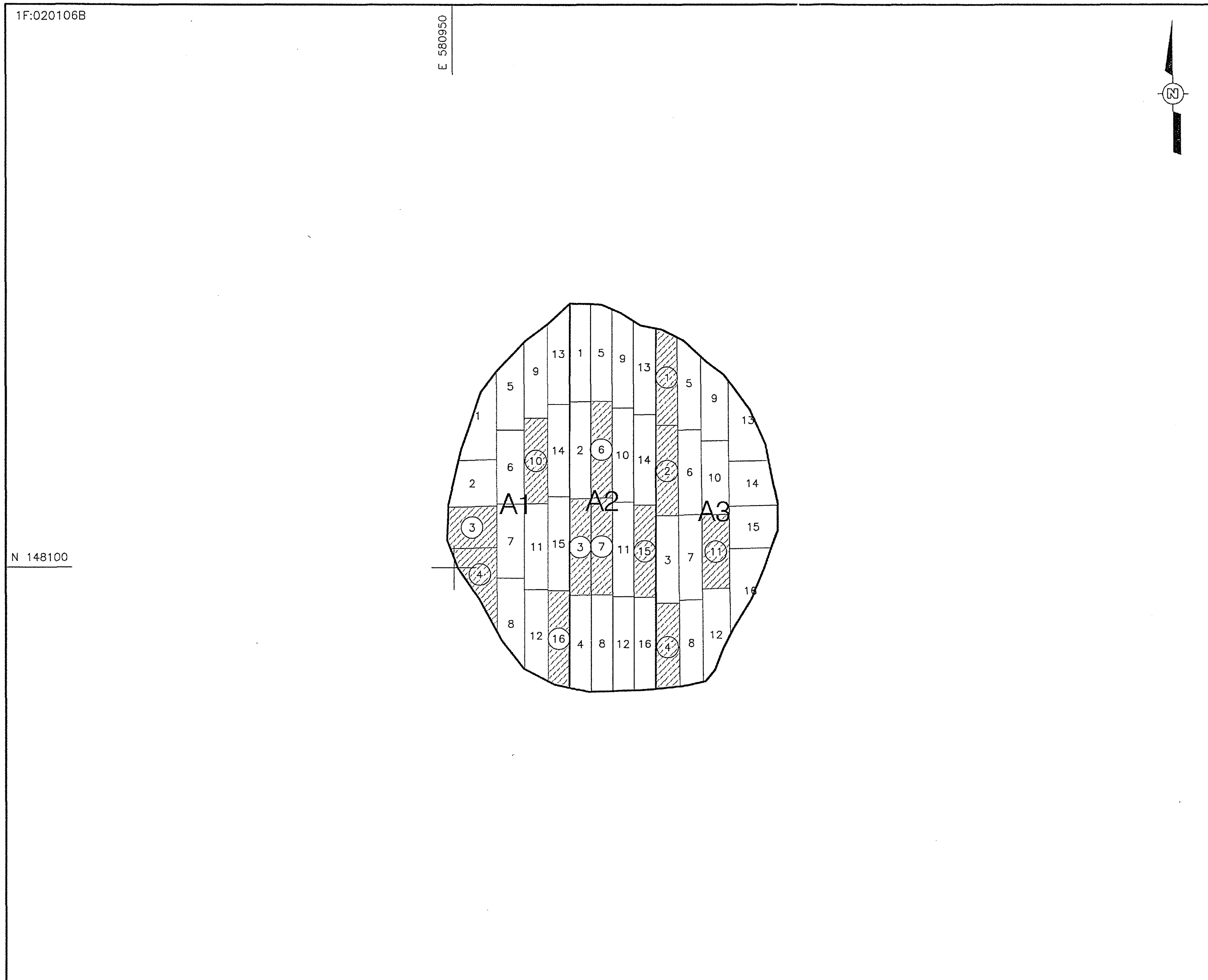
Attachment 3
Originator G. CRUZ
Chkd By AG
Calc. No. 0160F-CA-V0242

Sheet No. 1 of 3
Date 02/06/06
Date 2/6/06
Rev. No. 0

ATTACHMENT 3

U.S DEPARTMENT OF ENERGY
DOE RICHLAND OPERATIONS OFFICE
RIVIER CORRIDOR CLOSURE CONTRACT

100-F AREA
100 AREA REMEDIAL DESIGN
116-F-8 OUTFALL STRUCTURE
SHALLOW ZONE SAMPLING PLAN



SCALE 1:200
2 0 2 4 8 meters

NOTES

1. DEEP ZONE NODE AREAS ARE APPROXIMATELY 4.79 SQUARE METERS.
2. SAMPLES ARE TAKEN FROM THE APPROXIMATE CENTER OF EACH NODE.
3. THE DEEP ZONE CONSISTS OF SAMPLING AREAS A1, A2, AND A3 WITHIN DECISION SUBUNIT 1.

LEGEND

(8) VARIANCE AND VERIFICATION SAMPLING NODE

SAMPLE LOCATION TABLE

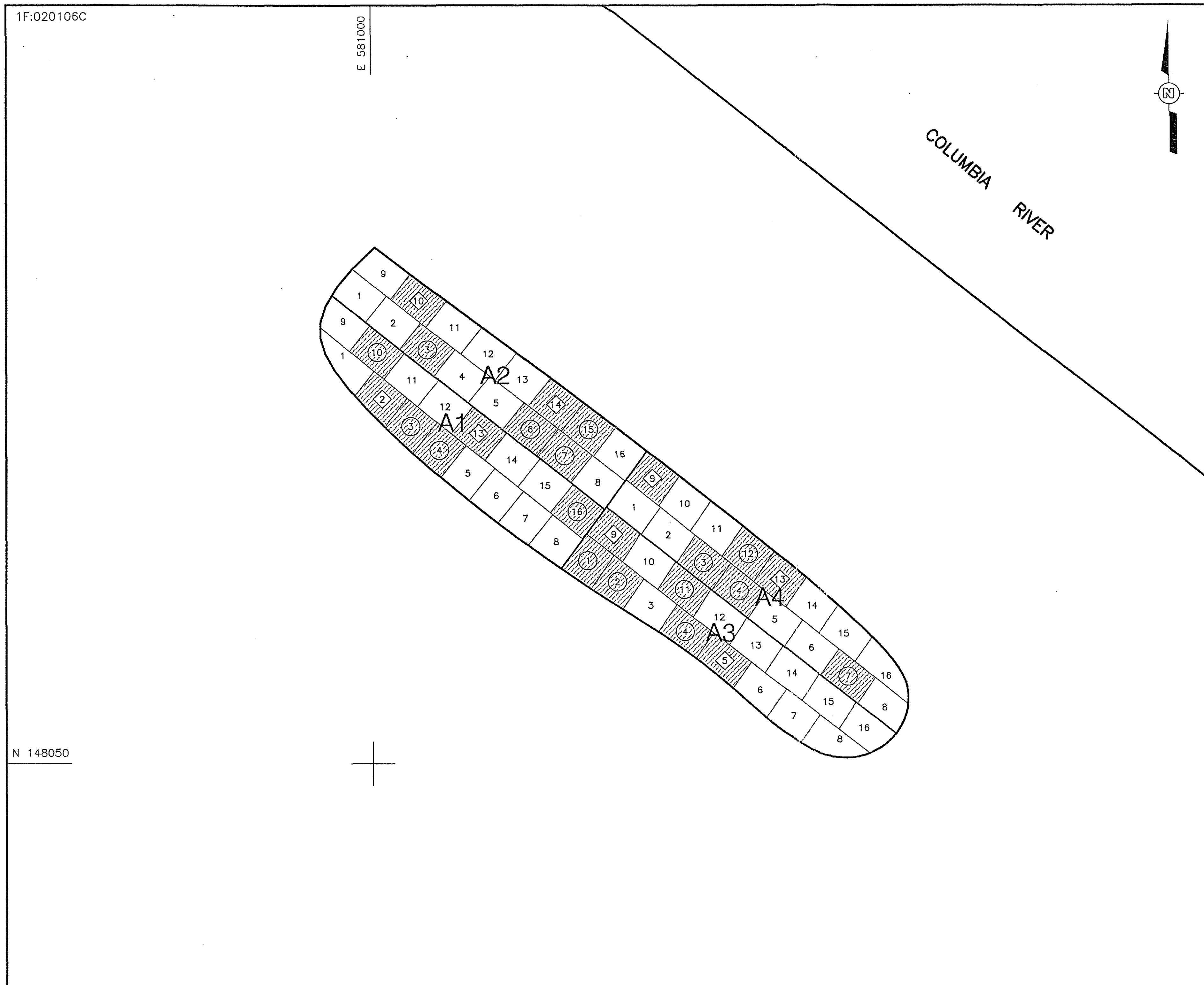
DECISION SUBUNIT	SAMPLING AREA	SAMPLE NODE	NORTHING	EASTING
1	A1	D-A1-3	148101.95	580950.87
		D-A1-4	148099.66	580951.25
		D-A1-10	148105.20	580953.98
		D-A1-16	148096.53	580955.07
	A2	D-A2-3	148100.99	580956.11
		D-A2-6	148105.75	580957.13
		D-A2-7	148101.02	580957.13
		D-A2-15	148100.80	580959.22
	A3	D-A3-1	148109.30	580960.31
		D-A3-2	148104.72	580960.31
		D-A3-4	148096.12	580960.31
		D-A3-11	148100.78	580962.69

Attachment 3 Sheet No. 2 of 3
Originator G. Cruz Date 02/06/06
Chk'd By CAB Date 2/6/06
Calc. No. 0100F-CA-V0242 Rev. No. 0

ATTACHMENT 3

U.S DEPARTMENT OF ENERGY
DOE RICHLAND OPERATIONS OFFICE
RIVIER CORRIDOR CLOSURE CONTRACT

100-F AREA
100 AREA REMEDIAL DESIGN
116-F-8 OUTFALL STRUCTURE
DEEP ZONE SAMPLING PLAN



NOTES

1. OVERBURDEN NODE AREAS ARE APPROXIMATELY 14.17 SQUARE METERS.
2. SAMPLES ARE TAKEN FROM THE APPROXIMATE CENTER OF EACH NODE.
3. THE OVERBURDEN CONSISTS OF SAMPLING AREAS A1, A2, A3, AND A4 WITHIN DECISION SUBUNIT 1.

LEGEND

VARIANCE AND VERIFICATION SAMPLING NODE

VERIFICATION SAMPLING NODE

SAMPLE LOCATION TABLE

DECISION SUBUNIT	SAMPLING AREA	SAMPLE NODE	NORTHING	EASTING
1	A1	0-A1-2	148085.83	581001.00
		0-A1-3	148083.14	581003.82
		0-A1-4	148080.79	581006.59
		0-A1-10	148090.44	581000.52
		0-A1-13	148082.44	581010.39
		0-A1-16	148074.76	581019.83
	A2	0-A2-3	148090.72	581005.44
		0-A2-6	148082.84	581015.36
		0-A2-7	148080.24	581018.63
		0-A2-10	148095.56	581004.61
		0-A2-14	148085.27	581017.82
		0-A2-15	148082.83	581020.97
	A3	0-A3-1	148069.98	581020.82
		0-A3-2	148067.89	581023.73
		0-A3-4	148063.02	581030.34
		0-A3-5	148060.14	581034.18
		0-A3-9	148072.54	581023.38
		0-A3-11	148067.16	581030.28
	A4	0-A4-3	148069.76	581032.16
		0-A4-4	148067.01	581035.62
		0-A4-7	148058.60	581046.18
		0-A4-9	148078.01	581027.20
		0-A4-12	148070.63	581036.54
		0-A4-13	148068.15	581039.62

Attachment 3 Sheet No. 3 of 3
Originator G. CRUZ Date 02/06/06
Chk'd By CAR Date 2/6/06
Calc. No. 0100F-CA-V0242 Rev. No. 0

ATTACHMENT 3

SCALE 1:400
4 0 4 8 16 meters

U.S DEPARTMENT OF ENERGY
DOE RICHLAND OPERATIONS OFFICE
RIVIER CORRIDOR CLOSURE CONTRACT

100-F AREA
100 AREA REMEDIAL DESIGN
116-F-8 OUTFALL STRUCTURE
OVERBURDEN SAMPLING PLAN

CALCULATION COVER SHEET

Project Title 100 F Area Remedial Action **Job No.** 14655

Area 100 F

Discipline Environmental ***Calc. No.** 0100F-CA-V0253

Subject **116-F-8 Outfall Structure Variance Calculation**

Computer Program MS 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	2	R.T. Coffman RT 5/25/06	S.W. Callison SW Callison 6-7-06	M.A. Buckmaster	M.A. Buckmaster	6/7/06

SUMMARY OF REVISION

WCH-DE-018 (04/14/2006) *Obtain Calc. No. from R&DC and Form from Intranet

CALCULATION SHEET

Washington Closure Hanford

Originator	R. T. Coffman	Date	5/2/2006	Calc. No.	0100F-CA-V0253	Rev. No.	0
Project	100-F Remedial Action	Job No.	14655	Checked	S. W. Callison SWC	Date	6-7-06
Subject	116-F-8 Outfall Structure Variance Calculation					Sheet No.	1 of 2

Conclusion:
The required number of samples calculated (1sample) for each decision sub-unit is less than the default number (4 samples) specified in the DOE/RL-96-22, Rev 4. Therefore, the default number of samples will be collected from each shallow zone decision sub-unit.

Problem:
Calculate the number of close out samples required for 116-F-8 Outfall Shallow Unit verification sampling as required in "100 Area Remedial Action Sampling and Analysis Plan" (DOE/RL-96-22, Rev 4) and "Instruction Guide for the Remediation of 100 Areas Waste Sites" (0100X-IG-G0001, Rev 5).

Given:
1) Sample locations for the 116-F-8 Outfall Shallow Decision Unit are identified on the 116-F-8 Outfall Shallow Zone Sample Design, Calculation number 0100F-CA-V0242, Rev. 0.
2) Lookup values from DOE/RL-96-22, Rev 4.
3) Sample Design requirements from DOE/RL-96-22, Rev 4 and 0100X-IG-G0001, Rev 5.
4) Field sampling information from sampling logbook EL-1174.

Solution:
Calculation methodology is described in Appendix A of DOE/RL-96-22, Rev 4. Data from attached worksheets are used to calculate the required number of closeout samples. Variance calculation is based on the same three isotopes used to develop the statistical approach in DOE/RL-96-22, Rev 4. The statistical design is based on the premise that these isotopes are the predominant components of the contamination and are representative of the contamination distribution.

Sheet No.	Contents	Topic
1	Calc. Summary	Summary of Calc Brief
2	Shallow Zone	Required Number of Samples Calculation

Calc. Summary

CALCULATION SHEET

Washington Closure Hanford

Originator	R. T. Coffman	Date	5/2/2006	Calc. No.	0100F-CA-V0253	Rev. No.	0
Project	100-F Remedial Action	Job No.	14655	Checked	S. W. Callison SWC	Date	6-7-06
Subject	116-F-8 Outfall Structure Variance Calculation					Sheet No.	2 of 2

Statistical Evaluation of Analytical Data

The required number of samples resulting from the calculation is highlighted at the bottom of the page.
Each value is reflective of the specific analyte evaluated.
The highest value of the three evaluations is used to determine the required number of samples as compared against the default of four.
Sample locations are from Calculation 0100F-CA-V0242.
Mean, Standard Deviation, t, and Number of Samples formulas are from DOE/RL-96-22, Appendix A.

Decision Unit: 116-F-8 Outfall Structure Shallow Zone
Samples values from GEA analysis
Sample Areas , A1 thru A4

			Constituent					
Sample #	**Sample Date**	**Location**	**Cobalt-60**	Q	**Cs-137**	Q	***Europium-152***	Q
			pCi/g		pCi/g		pCi/g	
Look-up Value (HT) ==========>			**1.4**		**6.2**		**3.3**	
J112M8	2/7/2006	S-A1-2	0.097	U	0.11	U	0.28	U
J112M9	2/7/2006	S-A1-3	0.071	U	0.068	U	0.24	U
J112N0	2/7/2006	S-A1-4	0.085	U	0.072	U	0.19	U
J112N1	2/7/2006	S-A1-10	0.086	U	0.08	U	0.22	U
J112N2	2/7/2006	S-A1-13	0.054	U	0.053	U	0.13	U
J112N3	2/7/2006	S-A1-16	0.093	U	0.082	U	0.21	U
J112N4	2/7/2006	S-A2-3	0.072	U	0.058	U	0.13	U
J112N5	2/7/2006	S-A2-6	0.052	U	0.043	U	0.17	U
J112N6	2/7/2006	S-A2-7	0.045	U	0.039	U	0.096	U
J112N7	2/7/2006	S-A2-10	0.058	U	0.055	U	0.14	U
J112N8	2/7/2006	S-A2-14	0.039	U	0.037	U	0.085	U
J112N9	2/7/2006	S-A2-15	0.078	U	0.073	U	0.17	U
J112P0	2/7/2006	S-A3-1	0.076	U	0.07	U	0.19	U
J112P1	2/7/2006	S-A3-2	0.074	U	0.076	U	0.2	U
J112P2	2/7/2006	S-A3-4	0.066	U	0.06	U	0.22	U
J112P3	2/7/2006	S-A3-5	0.059	U	0.072	U	0.16	U
J112P4	2/7/2006	S-A3-9	0.07	U	0.061	U	0.15	U
J112P5	2/7/2006	S-A3-11	0.052	U	0.038	U	0.1	U
J112P6	2/7/2006	S-A4-3	0.076	U	0.065	U	0.18	U
J112P7	2/7/2006	S-A4-4	0.079	U	0.075	U	0.16	U
J112P8	2/7/2006	S-A4-7	0.061	U	0.066	U	0.23	U
J112P9	2/7/2006	S-A4-9	0.066	U	0.063	U	0.17	U
J112R0	2/7/2006	S-A4-12	0.066	U	0.05	U	0.14	U
J112R1	2/7/2006	S-A4-13	0.037	U	0.034	U	0.087	U
Mean (LV) ==========>			0.07		0.06		0.17	
Standard Deviation (S) ==========>			0.02		0.02		0.05	
α (5%) ==========>			1.645		1.645		1.645	
β (20%) ==========>			0.842		0.842		0.842	
Number of Samples ==========>			**1**		**1**		**1**	

116-F-8 Outfall Structure

CALCULATION COVER SHEET

Project Title 100 F Area Remedial Action **Job No.** 14655

Area 100 F

Discipline Environmental ***Calc. No.** 0100F-CA-V254

Subject **116-F-8 Outfall Structure Overburden Variance Calculation**

Computer Program MS 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	2	R.T. Coffman RT Coffman 6/7/06	S.W. Callison SW Callison 6-7-06	M.A. Buckmaster	M.A. Buckmaster	6/7/06

SUMMARY OF REVISION

WCH-DE-018 (04/14/2006) *Obtain Calc. No. from R&DC and Form from Intranet

CALCULATION SHEET

Washington Closure Hanford

Originator	R. T. Coffman	Date	5/9/2006	Calc. No.	0100F-CA-V0254	Rev. No.	0
Project	100-F Remedial Action	Job No.	14655	Checked	S. W. Callison SWC	Date	6-7-06
Subject	116-F-8 Outfall Structure Overburden Variance Calculation					Sheet No.	1 of 2

Conclusion:
The required number of samples calculated (1sample) for each decision sub-unit is less than the default number (4 samples) specified in the DOE/RL-96-22, Rev 4. Therefore, the default number of samples will be collected from each overburden decision sub-unit.

Problem:
Calculate the number of close out samples required for 116-F-8 Outfall Structure Overburden Unit verification sampling as required in "100 Area Remedial Action Sampling and Analysis Plan" (DOE/RL-96-22, Rev 4) and "Instruction Guide for the Remediation of 100 Areas Waste Sites" (0100X-IG-G0001, Rev 5).

Given:
1) Sample locations for the 116-F-8 Outfall Structure Overburden Decision Unit are identified on the 116-F-8 Outfall Structure Overburden Sample Design, Calculation number 0100F-CA-V0242, Rev. 0.
2) Lookup values from DOE/RL-96-22, Rev 4.
3) Sample Design requirements from DOE/RL-96-22, Rev 4 and 0100X-IG-G0001, Rev 5.
4) Field sampling information from sampling logbook EL-1174.

Solution:
Calculation methodology is described in Appendix A of DOE/RL-96-22, Rev 4. Data from attached worksheets are used to calculate the required number of closeout samples. Variance calculation is based on the same three isotopes used to develop the statistical approach in DOE/RL-96-22, Rev 4. The statistical design is based on the premise that these isotopes are the predominant components of the contamination and are representative of the contamination distribution.

Sheet No.	Contents	Topic
1	Calc. Summary	Summary of Calc Brief
2	Overburden Calc Sheet	Required Number of Samples Calculation

CALCULATION SHEET

Washington Closure Hanford

Originator	R. T. Coffman	Date	5/9/2006	Calc. No.	0100F-CA-V0254	Rev. No.	0
Project	100-F Remedial Action	Job No.	14655	Checked	S. W. Callison SWC	Date	6-7-06
Subject	116-F-8 Outfall Structure Overburden Variance Calculation					Sheet No.	2 of 2

Statistical Evaluation of Analytical Data

The required number of samples resulting from the calculation is highlighted at the bottom of the page.
Each value is reflective of the specific analyte evaluated.
The highest value of the three evaluations is used to determine the required number of samples as compared against the default of four.
Sample locations are from Calculation 0100F-CA-V0242.
Mean, Standard Deviation, *t*, and Number of Samples formulas are from DOE/RL-96-22, Appendix A.

Decision Unit: 116-F-8 Outfall Structure Overburden
Samples values from GEA analysis
Sample Areas , A1 thru A4

			Constituent					
Sample #	**Sample Date**	**Location**	**Cobalt-60**	Q	**Cs-137**	Q	**Europium-152**	Q
			pCi/g		pCi/g		pCi/g	
Look-up Value (HT) ==========>			**1.4**		**6.2**		**3.3**	
J112R2	2/1/2006	O-A1-2	0.09	U	0.158		0.609	
J112R3	2/1/2006	O-A1-3	0.054	U	0.097		0.765	
J112R4	2/1/2006	O-A1-4	0.11	U	0.086	U	0.21	U
J112R5	2/1/2006	O-A1-10	0.075	U	0.081	U	0.195	
J112R6	2/1/2006	O-A1-13	0.069	U	0.079	U	0.29	U
J112R7	2/1/2006	O-A1-16	0.096	U	0.11	U	0.27	U
J112R8	2/1/2006	O-A2-3	0.048	U	0.053	U	0.12	U
J112R9	2/1/2006	O-A2-6	0.12	U	0.087	U	0.23	U
J112T0	2/1/2006	O-A2-7	0.071	U	0.076	U	0.25	U
J112T1	2/1/2006	O-A2-10	0.064	U	0.07	U	0.16	U
J112T2	2/1/2006	O-A2-14	0.074	U	0.066	U	0.18	U
J112T3	2/1/2006	O-A2-15	0.044	U	0.045	U	0.12	U
J112T4	2/1/2006	O-A3-1	0.092	U	0.10	U	0.49	
J112T5	2/1/2006	O-A3-2	0.079	U	0.079	U	0.29	U
J112T6	2/1/2006	O-A3-4	0.1	U	0.074	U	0.22	U
J112T7	2/1/2006	O-A3-5	0.098	U	0.1	U	0.26	U
J112T8	2/1/2006	O-A3-9	0.062	U	0.057	U	0.15	U
J112T9	2/1/2006	O-A3-11	0.09	U	0.089	U	0.18	U
J112V0	2/1/2006	O-A4-3	0.061	U	0.065	U	0.24	U
J112V1	2/1/2006	O-A4-4	0.082	U	0.082	U	0.18	U
J112V2	2/1/2006	O-A4-7	0.091	U	0.12	U	0.22	U
J112V3	2/1/2006	O-A4-9	0.049	U	0.045	U	0.12	U
J112V4	2/1/2006	O-A4-12	0.098	U	0.094	U	0.17	U
J112V5	2/1/2006	O-A4-13	0.06	U	0.072	U	0.16	U
Mean (LV) ==========>			0.08		0.08		0.25	
Standard Deviation (S) ==========>			0.02		0.02		0.16	
α (5%) ==========>			1.645		1.645		1.645	
β (20%) ==========>			0.842		0.842		0.842	
Number of Samples ==========>			**1**		**1**		**1**	

116-F-8 Outfall Overburden

CALCULATION COVER SHEET

Project Title	100-F Area Field Remediation	**Job No.**	14655
Area	100-F		
Discipline	Environmental	***Calc. No.**	0100F-CA-V0249
Subject	116-F-8 Waste Site Cleanup Verification 95% UCL Calculations		
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 Sheets = 9 Attm. 1 = 2 Total = 12	J. M. Capron 5/15/06	T. M. Blakley 5/15/06	L. M. Dittmer 5/15/06	S. W. Callison	5-18-06

SUMMARY OF REVISIONS

WCH-DE-018 (4/14/06) * Obtain Calc No. from R&DC and Form from Intranet

CALCULATION SHEET

Washington Closure Hanford

Originator J. M. Capron **Date** 05/15/06 **Calc. No.** 0100F-CA-V0249 **Rev. No.** 0
Project 100-F Area Field Remediation **Job No.** 14655 **Checked** T. M. Blakley **Date** 5/15/06
Subject 116-F-8 Waste Site Cleanup Verification 95% UCL Calculations **Sheet No.** 1 of 9

Summary

Purpose:
Calculate the 95% upper confidence limit (UCL) values to evaluate compliance with cleanup standards for the subject site. Also, calculate the carcinogenic risk for applicable nonradionuclide analytes, perform the *Washington Administrative Code* (WAC) 173-340-740(7)(e) 3-part test for nonradionuclide analytes and calculate the relative percent difference (RPD) for primary-duplicate and primary-split sample pairs for each contaminant of potential concern (COPC), as necessary.

Table of Contents:

Given/References:

1) Sample Results (Attachment 1).
2) Background values and remedial action goals (RAGs) are taken from DOE-RL (2005b), DOE-RL (2001), and Ecology (2005).
3) DOE-RL, 2001, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, DOE/RL-92-24, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
4) DOE-RL, 2005a, *100 Area Remedial Action Sampling and Analysis Plan* (SAP), DOE/RL-96-22, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
5) DOE-RL, 2005b, *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP), DOE/RL-96-17, Rev. 5, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
6) Ecology, 1992, *Statistical Guidance for Ecology Site Managers*, Publication #92-54, Washington Department of Ecology, Olympia, Washington.
7) Ecology, 1993, *Statistical Guidance for Ecology Site Managers, Supplement S-6, Analyzing Site or Background Data with Below-detection Limit or Below-PQL Values (Censored Data Sets)*, Publication #92-54, Washington Department of Ecology, Olympia, Washington.
8) Ecology, 2005, *Cleanup Levels and Risk Calculations (CLARC) Database*, Washington State Department of Ecology, Olympia, Washington, <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.
9) 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.
10) WAC 173-340, 1996, "Model Toxic Control Act - Cleanup," *Washington Administrative Code.*

Solution:
Calculation methodology is described in Ecology Pub. #92-54 (Ecology 1992, 1993), below, and in the RDR/RAWP (DOE-RL 2005b). Use data from attached worksheets to calculate the 95% UCL, hazard quotients, and excess carcinogenic risk, and RPD values and perform the WAC 173-340 3-part test for nonradionuclides.

Calculation Description:
The subject calculations were performed on data from soil verification samples from the subject waste site. The data were entered into an EXCEL 2003 spreadsheet and calculations performed by using the built-in spreadsheet functions and/or creating formulae within the cells. The statistical evaluation of data for use in accordance with the RDR/RAWP (DOE-RL 2005b) is documented by this calculation. Split and duplicate RPD results are used in evaluation of data quality within the remaining sites verification package (RSVP) for this site.

CALCULATION SHEET

Washington Closure Hanford

Originator J. M. Capron **Date** 05/15/06 **Calc. No.** 0100F-CA-V0249 **Rev. No.** 0
Project 100-F Area Field Remediation **Job No.** 14655 **Checked** T. M. Blakley **Date** 5/15/06
Subject 116-F-8 Waste Site Cleanup Verification 95% UCL Calculations **Sheet No.** 2 of 9

Summary (continued)

Methodology:

For nonradioactive analytes with ≤50% of the data below detection limits and all radionuclide analytes, the statistical value calculated to evaluate the effectiveness of cleanup is the 95% UCL. The 95% UCL values were calculated only for the site COPCs (as identified in the SAP [DOE-RL 2005a]) and for analytes detected by the primary laboratory. The 95% UCL values were not calculated for radium-226, radium-228, thorium-228, thorium-232, and potassium-40, as these isotopes are not related to the operational history of the site and thus not considered COPCs. For nonradioactive analytes with >50% of the data below detection limits, the maximum detected value for the data set is used instead of the 95% UCL.

All nonradionuclide data reported as being undetected are set to ½ the detection limit value for calculation of the statistics (Ecology 1993). For radionuclide data, calculation of the statistics was done on the reported value. In cases where the laboratory does not report a value below the minimum detectable activity (MDA), half of the MDA is used in the calculation. For the statistical evaluation of duplicate sample pairs, the samples are averaged before being included in the data set, after adjustments for censored data as described above.

For nonradionuclides, the WAC 173-340 statistical guidance suggests that a test for distributional form be performed on the data and the 95% UCL calculated on the appropriate distribution using Ecology software. For nonradionuclide small data sets ($n < 10$) and all radionuclide data sets, as for the subject site, the calculations are performed assuming nonparametric distribution, so no tests for distribution are performed. For nonradionuclide data sets of ten or greater, distributional testing and calculation of the 95% UCL is done using Ecology's MTCAStat software (Ecology 1993).

The WAC 173-340-740(7)(e) 3-part test is performed for nonradionuclide analytes only and determines if:
1) the 95% UCL exceeds the most stringent cleanup limit for each COPC/COC,
2) greater than 10% of the raw data exceed the most stringent cleanup limit for each COPC/COC,
3) the maximum value of the raw data set exceeds two times the most stringent cleanup limit for each COPC/COC.

The WAC 173-340-740(7)(e) 3-part test is not performed for data sets where the statistical value defaults to the maximum value, as direct comparison of the maximum against site RAGs (within the RSVP) is more conservative.

The RPD is calculated when both the primary value and the duplicate 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, listed in Table II-1 of the SAP (DOE-RL 2005a). 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:

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

where, M = main sample value S = split (or duplicate) sample value

For quality assurance/quality control (QA/QC) split and 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 regulatory 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, as necessary.

Washington Closure Hanford **CALCULATION SHEET**

Originator J. M. Capron JMC **Date** 05/15/06 **Calc. No.** 0100F-CA-V0249 **Rev. No.** 0
Project 100-F Area Field Remediation **Job No.** 14655 **Checked** T. M. Blakley TMB **Date** 5/15/06
Subject 116-F-8 Waste Site Cleanup Verification 95% UCL Calculations **Sheet No.** 3 of 9

Summary (continued)

Results:
The results presented in the summary tables that follow are for use in the RSVP for this site.

Results Summary

Analyte	Shallow Zone		Deep Zone		Overburden		Units
	Result	Qualifier	Result	Qualifier	Result	Qualifier	
Hexavalent chromium	0.27		0.22	U	0.22		mg/kg
Cobalt-60	0.047	U	0.081	U	0.049	U	pCi/g
Europium-152	0.100	U	2.37		0.15	U	pCi/g
Europium-154	0.14	U	0.22	U	0.14	U	pCi/g
Europium-155	0.12	U	0.16	U	0.08	U	pCi/g
Cesium-137	0.044	U	0.249		0 (< BG)	U	pCi/g

BG = background
U = undetected (in all samples submitted to the primary laboratory)

WAC 173-340 Evaluation (Shallow Zone)

3-Part Test:
95% UCL > Cleanup Limit? NO
> 10% above Cleanup Limit? NO
Any sample > 2x Cleanup Limit? NO

All nonradionuclide COPC concentrations satisfy the 3-part test criteria.

Risk Estimate:
Nonrad noncarcinogenic index sum: 1.1E-03
Nonrad carcinogenic risk: 1.3E-07

WAC 173-340 Evaluation (Deep Zone)

3-Part Test:
95% UCL > Cleanup Limit? NA
> 10% above Cleanup Limit? NA
Any sample > 2x Cleanup Limit? NA

Because no nonradionuclide COPCs were detected, performance of the 3-part test is not required.

WAC 173-340 Evaluation (Overburden)

3-Part Test:
95% UCL > Cleanup Limit? NO
> 10% above Cleanup Limit? NO
Any sample > 2x Cleanup Limit? NO

All nonradionuclide COPC concentrations satisfy the 3-part test criteria.

Risk Estimate:
Nonrad noncarcinogenic index sum: 9.4E-04
Nonrad carcinogenic risk: 1.1E-07

Relative Percent Difference Results

Relative percent difference analysis was not required for any primary-duplicate or primary-split sample pairs.

CALCULATION SHEET

Washington Closure Hanford

Originator J. M. Capron **Date** 05/15/06 **Calc. No.** 0100F-CA-V0249 **Rev. No.** 0
Project 100-F Area Field Remediation **Job No.** 14655 **Checked** T. M. Blakley **Date** 5/15/06
Subject 116-F-8 Waste Site Cleanup Verification 95% UCL Calculations **Sheet No.** 4 of 9

116-F-8 Shallow Zone Sample Data

Sampling Area	HEIS Number	Sample Date	Hexavalent Chromium mg/kg	Q	PQL	Cobalt-60 pCi/g	Q	MDA	Europium-152 pCi/g	Q	MDA
A4	J117N6	2/23/2006	0.35		0.20	0.082	U	0.082	0.17	U	0.17
Duplicate of J117N6	J117N7	2/23/2006	0.21		0.20	0.069	U	0.069	0.14	U	0.14
A1	J117N3	2/23/2006	0.22	U	0.22	0.099	U	0.099	0.22	U	0.22
A2	J117N4	2/23/2006	0.20	U	0.20	0.089	U	0.089	0.17	U	0.17
A3	J117N5	2/23/2006	0.26		0.21	0.071	U	0.071	0.15	U	0.15

Statistical Computation Input Data

Sampling Area	HEIS Number	Sample Date	Hexavalent Chromium mg/kg	Cobalt-60 pCi/g	Europium-152 pCi/g
A4	J117N6/ J117N7	2/23/2006	0.28	0.038	0.078
A1	J117N3	2/23/2006	0.11	0.050	0.11
A2	J117N4	2/23/2006	0.10	0.045	0.085
A3	J117N5	2/23/2006	0.26	0.036	0.075

Statistical Computations

	Hexavalent Chromium	Cobalt-60	Europium-152
95% UCL value based on	Small data set. Use nonparametric z-stat.	Radionuclide data set. Use nonparametric z-stat.	Radionuclide data set. Use nonparametric z-stat.
N	4	4	4
% < Detection limit	50%	100%	100%
Mean	0.19	0.042	0.087
Standard deviation	0.10	0.006	0.016
Z-statistic	1.645	1.645	1.645
95% UCL on mean	0.27	0.047 U	0.100 U
Maximum value	0.35	0.099 U	0.22 U
Statistical value	0.27	0.047 U	0.100 U
Background	NA	NA	NA
Statistical value above background	0.27	0.047 U	0.100 U
Most Stringent Cleanup Limit for nonradionuclide and RAG type	2 River Protection		
WAC 173-340 3-PART Test			
95% UCL > Cleanup Limit?	NO		
> 10% above Cleanup Limit?	NO		
Any sample > 2X Cleanup Limit?	NO		
RISK EVALUATION			
WAC 173-340 Non-Carcinogenic Cleanup:	240		
Hazard quotient for each nonradionuclide:	1.1E-03		
WAC 173-340 Carcinogenic Cleanup:	2.1		
Risk for each carcinogenic nonradionuclide:	1.3E-07		
WAC 173-340 Compliance? YES	The data set meets the 3-part test criteria when compared to the most stringent cleanup limit.		
Hazard quotient sum: 1.1E-03			
Carcinogenic risk sum: 1.3E-07			

Split-Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Hexavalent Chromium mg/kg	Q	PQL	Cobalt-60 pCi/g	Q	MDA	Europium-152 pCi/g	Q	MDA
A4	J117N6	2/23/2006	0.35		0.20	0.082	U	0.082	0.17	U	0.17
Duplicate of J117N6	J117N7	2/23/2006	0.21		0.20	0.069	U	0.069	0.14	U	0.14
Split of J117N6	J117X2	2/23/06	0.350	U	0.350	-0.00240	U	0.0196	-0.00201	U	0.0443
TDL			0.5			0.05			0.1		
Duplicate Analysis	Both > PQL/MDA?		Yes (continue)			No-Stop (acceptable)			No-Stop (acceptable)		
	Both > 5xTDL?		No-Stop (acceptable)								
	RPD										
Split Analysis	Both > PQL/MDA?		No-Stop (acceptable)			No-Stop (acceptable)			No-Stop (acceptable)		
	Both > 5xTDL?										
	RPD										

Note: Radiological analytical methods use statistically-determined floating calibration curves that are not forced through the origin; therefore, negative values are routinely reported for undetected analytes. This does not diminish the usability of the data.

HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
NA = not applicable
PQL = practical quantitation limit
Q = qualifier
RAG = remedial action goal
RPD = relative percent difference
TDL = target detection limit
U = undetected
UCL = upper confidence limit
WAC = *Washington Administrative Code*

CALCULATION SHEET

Washington Closure Hanford

Originator J. M. Capron **Date** 05/15/06 **Calc. No.** 0100F-CA-V0249 **Rev. No.** 0
Project 100-F Area Field Remediation **Job No.** 14655 **Checked** T. M. Blakley **Date** 5/15/06
Subject 116-F-8 Waste Site Cleanup Verification 95% UCL Calculations **Sheet No.** 5 of 9

116-F-8 Shallow Zone Sample Data (continued)

Sampling Area	HEIS Number	Sample Date	Europium-154			Europium-155			Cesium-137		
			pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA
A4	J117N6	2/23/2006	0.32	U	0.32	0.18	U	0.18	0.079	U	0.079
Duplicate of J117N6	J117N7	2/23/2006	0.23	U	0.23	0.18	U	0.18	0.065	U	0.065
A1	J117N3	2/23/2006	0.28	U	0.28	0.26	U	0.26	0.098	U	0.098
A2	J117N4	2/23/2006	0.19	U	0.19	0.15	U	0.15	0.068	U	0.068
A3	J117N5	2/23/2006	0.19	U	0.19	0.24	U	0.24	0.062	U	0.062

Statistical Computation Input Data

Sampling Area	HEIS Number	Sample Date	Europium-154 pCi/g	Europium-155 pCi/g	Cesium-137 pCi/g
A4	J117N6/ J117N7	2/23/2006	0.14	0.090	0.036
A1	J117N3	2/23/2006	0.14	0.13	0.049
A2	J117N4	2/23/2006	0.095	0.075	0.034
A3	J117N5	2/23/2006	0.095	0.12	0.031

Statistical Computations

	Europium-154			Europium-155			Cesium-137		
95% UCL value based on	Radionuclide data set. Use nonparametric z-stat.			Radionuclide data set. Use nonparametric z-stat.			Radionuclide data set. Use nonparametric z-stat.		
N	4			4			4		
% < Detection limit	100%			100%			100%		
Mean	0.12			0.10			0.038		
Standard deviation	0.03			0.03			0.008		
Z-statistic	1.645			1.645			1.645		
95% UCL on mean	0.14	U		0.12	U		0.044	U	
Maximum value	0.32	U		0.26	U		0.098	U	
Statistical value	0.14	U		0.12	U		0.044	U	
Background	NA			NA			NA		
Statistical value above background	0.14	U		0.12	U		0.044	U	

Split-Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Europium-154			Europium-155			Cesium-137		
			pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA
A4	J117N6	2/23/2006	0.32	U	0.32	0.18	U	0.18	0.079	U	0.079
Duplicate of J117N6	J117N7	2/23/2006	0.23	U	0.23	0.18	U	0.18	0.065	U	0.065
Split of J117N6	J117X2	2/23/06	-0.0217	U	0.0635	0.0183	U	0.0436	-0.00667	U	0.0169
TDL			0.1			0.1			0.1		
Duplicate Analysis	Both > MDA?		No-Stop (acceptable)			No-Stop (acceptable)			No-Stop (acceptable)		
	Both > 5xTDL?										
	RPD										
Split Analysis	Both > MDA?		No-Stop (acceptable)			No-Stop (acceptable)			No-Stop (acceptable)		
	Both > 5xTDL?										
	RPD										

Note: Radiological analytical methods use statistically-determined floating calibration curves that are not forced through the origin; therefore, negative values are routinely reported for undetected analytes. This does not diminish the usability of the data.

HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
NA = not applicable
Q = qualifier
RPD = relative percent difference
TDL = target detection limit
U = undetected
UCL = upper confidence limit

CALCULATION SHEET

Washington Closure Hanford

Originator J. M. Capron Date 05/15/06 Calc. No. 0100F-CA-V0249 Rev. No. 0
Project 100-F Area Field Remediation Job No. 14655 Checked T. M. Blakley Date 5/15/06
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116-F-8 Deep Zone Sample Data

Sampling Area	HEIS Number	Sample Date	Hexavalent Chromium mg/kg	Q	PQL	Cobalt-60 pCi/g	Q	MDA	Europium-152 pCi/g	Q	MDA
A1	J117M3	2/9/06	0.21	U	0.21	0.098	U	0.098	0.21	U	0.21
Duplicate of J117M3	J117M6	2/9/06	0.22	U	0.22	0.095	U	0.095	0.22	U	0.22
A2	J117M4	2/9/06	0.22	U	0.22	0.16	U	0.16	1.82		0.18
A3	J117M5	2/9/06	0.21	U	0.21	0.14	U	0.14	2.10		0.49

Statistical Computation Input Data

Sampling Area	HEIS Number	Sample Date	Hexavalent Chromium mg/kg			Cobalt-60 pCi/g			Europium-152 pCi/g		
A1	J117M3/ J117M6	2/9/2006	0.11			0.048			0.11		
A2	J117M4	2/9/2006	0.11			0.080			1.82		
A3	J117M5	2/9/2006	0.11			0.070			2.10		

Statistical Computations

	Hexavalent Chromium			Cobalt-60			Europium-152		
95% UCL value based on	Small data set. Use nonparametric z-stat.			Radionuclide data set. Use nonparametric z-stat.			Radionuclide data set. Use nonparametric z-stat.		
N	3			3			3		
% < Detection limit	100%			100%			33%		
Mean	0.11			0.066			1.34		
Standard deviation	0.003			0.016			1.08		
Z-statistic	1.645			1.645			1.645		
95% UCL on mean	0.11	U		0.081	U		2.37		
Maximum value	0.22	U		0.16	U		2.10		
Statistical value	0.22	U		0.081	U		2.37		
Background	NA			NA			NA		
Statistical value above background	0.22	U		0.081	U		2.37		
Most Stringent Cleanup Limit for nonradionuclide and RAG type	2 River Protection								
WAC 173-340 3-PART Test									
95% UCL > Cleanup Limit?	NA								
> 10% above Cleanup Limit?	NA								
Any sample > 2X Cleanup Limit?	NA								
WAC 173-340 Compliance? YES	Because hexavalent chromium was not detected in any sample, the WAC 173-340 3-part test is not required.								

Split-Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Hexavalent Chromium mg/kg	Q	PQL	Cobalt-60 pCi/g	Q	MDA	Europium-152 pCi/g	Q	MDA
A1	J117M3	2/9/06	0.21	U	0.21	0.098	U	0.098	0.21	U	0.21
Duplicate of J117M3	J117M6	2/9/06	0.22	U	0.22	0.095	U	0.095	0.22	U	0.22
Split of J117M3	J117X0	2/9/06	0.350	U	0.350	0.000753	U	0.0161	0.195	U	0.0590
TDL			0.5			0.05			0.1		
Duplicate Analysis	Both > PQL/MDA?		No-Stop (acceptable)			No-Stop (acceptable)			No-Stop (acceptable)		
	Both > 5xTDL?										
	RPD										
Split Analysis	Both > PQL/MDA?		No-Stop (acceptable)			No-Stop (acceptable)			No-Stop (acceptable)		
	Both > 5xTDL?										
	RPD										

HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
NA = not applicable
PQL = practical quantitation limit
Q = qualifier
RAG = remedial action goal
RPD = relative percent difference
TDL = target detection limit
U = undetected
UCL = upper confidence limit
WAC = *Washington Administrative Code*

CALCULATION SHEET

Washington Closure Hanford

Originator J. M. Capron **Date** 05/15/06 **Calc. No.** 0100F-CA-V0249 **Rev. No.** 0
Project 100-F Area Field Remediation **Job No.** 14655 **Checked** T. M. Blakley **Date** 5/15/06
Subject 116-F-8 Waste Site Cleanup Verification 95% UCL Calculations **Sheet No.** 7 of 9

116-F-8 Deep Zone Sample Data (continued)

Sampling Area	HEIS Number	Sample Date	Europium-154			Europium-155			Cesium-137		
			pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA
A1	J117M3	2/9/06	0.27	U	0.27	0.24	U	0.24	0.084	U	0.084
Duplicate of J117M3	J117M6	2/9/06	0.27	U	0.27	0.21	U	0.21	0.082	U	0.082
A2	J117M4	2/9/06	0.30	U	0.30	0.23	U	0.23	0.273		0.084
A3	J117M5	2/9/06	0.45	U	0.45	0.33	U	0.33	0.16	U	0.16

Statistical Computation Input Data

Sampling Area	HEIS Number	Sample Date	Europium-154 pCi/g			Europium-155 pCi/g			Cesium-137 pCi/g		
A1	J117M3/ J117M6	2/9/2006	0.14			0.11			0.042		
A2	J117M4	2/9/2006	0.15			0.12			0.273		
A3	J117M5	2/9/2006	0.23			0.17			0.080		

Statistical Computations

	Europium-154			Europium-155			Cesium-137		
95% UCL value based on	Radionuclide data set. Use nonparametric z-stat.			Radionuclide data set. Use nonparametric z-stat.			Radionuclide data set. Use nonparametric z-stat.		
N	3			3			3		
% < Detection limit	100%			100%			67%		
Mean	0.17			0.13			0.132		
Standard deviation	0.05			0.03			0.124		
Z-statistic	1.645			1.645			1.645		
95% UCL on mean	0.22	U		0.16	U		0.249		
Maximum value	0.45	U		0.33	U		0.273		
Statistical value	0.22	U		0.16	U		0.249		
Background	NA			NA			NA		
Statistical value above background	0.22	U		0.16	U		0.249		

Split-Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Europium-154			Europium-155			Cesium-137		
			pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA
A1	J117M3	2/9/06	0.27	U	0.27	0.24	U	0.24	0.084	U	0.084
Duplicate of J117M3	J117M6	2/9/06	0.27	U	0.27	0.21	U	0.21	0.082	U	0.082
Split of J117M3	J117X0	2/9/06	0.00514	U	0.0555	0.0515	U	0.0471	-0.00171	U	0.0172
TDL			0.1			0.1			0.1		
Duplicate Analysis	Both > MDA?		No-Stop (acceptable)			No-Stop (acceptable)			No-Stop (acceptable)		
	Both > 5xTDL?										
	RPD										
Split Analysis	Both > MDA?		No-Stop (acceptable)			No-Stop (acceptable)			No-Stop (acceptable)		
	Both > 5xTDL?										
	RPD										

Note: Radiological analytical methods use statistically-determined floating calibration curves that are not forced through the origin; therefore, negative values are routinely reported for undetected analytes. This does not diminish the usability of the data.

HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
NA = not applicable
Q = qualifier
RPD = relative percent difference
TDL = target detection limit
U = undetected
UCL = upper confidence limit

CALCULATION SHEET

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Originator J. M. Capron JMC **Date** 05/15/06 **Calc. No.** 0100F-CA-V0249 **Rev. No.** 0
Project 100-F Area Field Remediation **Job No.** 14655 **Checked** T. M. Blakley TMB **Date** 5/15/06
Subject 116-F-8 Waste Site Cleanup Verification 95% UCL Calculations **Sheet No.** 8 of 9

116-F-8 Overburden Sample Data

Sampling Area	HEIS Number	Sample Date	Hexavalent Chromium mg/kg	Q	PQL	Cobalt-60 pCi/g	Q	MDA	Europium-152 pCi/g	Q	MDA
A1	J117M8	2/14/2006	0.20	U	0.20	0.10	U	0.10	0.32	U	0.32
Duplicate of J117M8	J117N2	2/14/2006	0.25		0.21	0.15	U	0.15	0.42	U	0.42
A2	J117M9	2/14/2006	0.22		0.20	0.093	U	0.093	0.19	U	0.19
A3	J117N0	2/14/2006	0.21	U	0.21	0.059	U	0.059	0.14	U	0.14
A4	J117N1	2/14/2006	0.22		0.20	0.090	U	0.090	0.20	U	0.20

Statistical Computation Input Data

Sampling Area	HEIS Number	Sample Date	Hexavalent Chromium mg/kg			Cobalt-60 pCi/g			Europium-152 pCi/g		
A1	J117M8/ J117N2	2/14/2006	0.18			0.063			0.19		
A2	J117M9	2/14/2006	0.22			0.047			0.095		
A3	J117N0	2/14/2006	0.11			0.030			0.070		
A4	J117N1	2/14/2006	0.22			0.045			0.10		

Statistical Computations

	Hexavalent Chromium			Cobalt-60			Europium-152		
95% UCL value based on	Small data set. Use nonparametric z-stat.			Radionuclide data set. Use nonparametric z-stat.			Radionuclide data set. Use nonparametric z-stat.		
N	4			4			4		
% < Detection limit	25%			100%			100%		
Mean	0.18			0.046			0.11		
Standard deviation	0.05			0.013			0.05		
Z-statistic	1.645			1.645			1.645		
95% UCL on mean	0.22			0.057	U		0.15	U	
Maximum value	0.25			0.15	U		0.42	U	
Statistical value	0.22			0.057	U		0.15	U	
Background	NA			0.008			NA		
Statistical value above background	0.22			0.049	U		0.15	U	
Most Stringent Cleanup Limit for nonradionuclide and RAG type	2 River Protection								
WAC 173-340 3-PART Test									
95% UCL > Cleanup Limit?	NO								
> 10% above Cleanup Limit?	NO								
Any sample > 2X Cleanup Limit?	NO								
RISK EVALUATION									
WAC 173-340 Non-Carcinogenic Cleanup:	240								
Hazard quotient for each nonradionuclide:	9.4E-04								
WAC 173-340 Carcinogenic Cleanup:	2.1								
Risk for each carcinogenic nonradionuclide:	1.1E-07								
WAC 173-340 Compliance? YES	The data set meets the 3-part test criteria when compared to the most stringent cleanup limit.								
Hazard quotient sum: 9.4E-04									
Carcinogenic risk sum: 1.1E-07									

Split-Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Hexavalent Chromium mg/kg	Q	PQL	Cobalt-60 pCi/g	Q	MDA	Europium-152 pCi/g	Q	MDA
A1	J117M8	2/14/2006	0.20	U	0.20	0.10	U	0.10	0.32	U	0.32
Duplicate of J117M8	J117N2	2/14/2006	0.25		0.21	0.15	U	0.15	0.42	U	0.42
Split of J117M8	J117X1	2/14/06	0.350	U	0.350	0.00359	U	0.0146	0.640		0.0351
TDL			0.5			0.05			0.1		
Duplicate Analysis: Both > PQL/MDA?			No-Stop (acceptable)			No-Stop (acceptable)			No-Stop (acceptable)		
Duplicate Analysis: Both > 5xTDL?											
Duplicate Analysis: RPD											
Split Analysis: Both > PQL/MDA?			No-Stop (acceptable)			No-Stop (acceptable)			No-Stop (acceptable)		
Split Analysis: Both > 5xTDL?											
Split Analysis: RPD											

HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
NA = not applicable
PQL = practical quantitation limit
Q = qualifier
RAG = remedial action goal
RPD = relative percent difference
TDL = target detection limit
U = undetected
UCL = upper confidence limit
WAC = *Washington Administrative Code*

CALCULATION SHEET

Washington Closure Hanford

Originator J. M. Capron **Date** 05/15/06 **Calc. No.** 0100F-CA-V0249 **Rev. No.** 0
Project 100-F Area Field Remediation **Job No.** 14655 **Checked** T. M. Blakley **Date** 5/15/06
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116-F-8 Overburden Sample Data (continued)

Sampling Area	HEIS Number	Sample Date	Europium-154			Europium-155			Cesium-137		
			pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA
A1	J117M8	2/14/2006	0.34	U	0.34	0.23	U	0.23	0.11	U	0.11
Duplicate of J117M8	J117N2	2/14/2006	0.44	U	0.44	0.29	U	0.29	0.14	U	0.14
A2	J117M9	2/14/2006	0.25	U	0.25	0.23	U	0.23	0.083	U	0.083
A3	J117N0	2/14/2006	0.19	U	0.19	0.16	U	0.16	0.053	U	0.053
A4	J117N1	2/14/2006	0.30	U	0.30	0.25	U	0.25	0.087	U	0.087

Statistical Computation Input Data

Sampling Area	HEIS Number	Sample Date	Europium-154 pCi/g			Europium-155 pCi/g			Cesium-137 pCi/g		
A1	J117M8/ J117N2	2/14/2006	0.20			0.13			0.063		
A2	J117M9	2/14/2006	0.125			0.12			0.042		
A3	J117N0	2/14/2006	0.095			0.080			0.027		
A4	J117N1	2/14/2006	0.15			0.13			0.044		

Statistical Computations

	Europium-154			Europium-155			Cesium-137		
95% UCL value based on	Radionuclide data set. Use nonparametric z-stat.			Radionuclide data set. Use nonparametric z-stat.			Radionuclide data set. Use nonparametric z-stat.		
N	4			4			4		
% < Detection limit	100%			100%			100%		
Mean	0.14			0.11			0.044		
Standard deviation	0.04			0.02			0.015		
Z-statistic	1.645			1.645			1.645		
95% UCL on mean	0.18	U		0.13	U		0.056	U	
Maximum value	0.44	U		0.29	U		0.14	U	
Statistical value	0.18	U		0.13	U		0.056	U	
Background	0.033			0.054			1.1		
Statistical value above background	0.14	U		0.08	U		0 (< BG)	U	

Split-Duplicate Analysis

Sampling Area	HEIS Number	Sample Date	Europium-154			Europium-155			Cesium-137		
			pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA
A1	J117M8	2/14/2006	0.34	U	0.34	0.23	U	0.23	0.11	U	0.11
Duplicate of J117M8	J117N2	2/14/2006	0.44	U	0.44	0.29	U	0.29	0.14	U	0.14
Split of J117M8	J117X1	2/14/06	0.0478	U	0.0509	0.0349	U	0.0398	0.0457		0.0131
TDL			0.1			0.1			0.1		
Duplicate Analysis	Both > MDA?		No-Stop (acceptable)			No-Stop (acceptable)			No-Stop (acceptable)		
	Both > 5xTDL?										
	RPD										
Split Analysis	Both > MDA?		No-Stop (acceptable)			No-Stop (acceptable)			No-Stop (acceptable)		
	Both > 5xTDL?										
	RPD										

BG = background
HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
NA = not applicable
Q = qualifier
RPD = relative percent difference
TDL = target detection limit
U = undetected
UCL = upper confidence limit

Attachment 1. 116-F-8 Verification Sampling Results.

Sample Location	HEIS Number	Sample Date	Americium-241			Cesium-137			Cobalt-60			Europium-152			Europium-154		
			pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA
SZ A1	J117N3	2/23/06	0.32	U	0.32	0.098	U	0.098	0.099	U	0.099	0.22	U	0.22	0.28	U	0.28
SZ A2	J117N4	2/23/06	0.17	U	0.17	0.068	U	0.068	0.089	U	0.089	0.17	U	0.17	0.19	U	0.19
SZ A3	J117N5	2/23/06	0.29	U	0.29	0.062	U	0.062	0.071	U	0.071	0.15	U	0.15	0.19	U	0.19
SZ A4	J117N6	2/23/06	0.18	U	0.18	0.079	U	0.079	0.082	U	0.082	0.17	U	0.17	0.32	U	0.32
Duplicate of J117N6	J117N7	2/23/06	0.23	U	0.23	0.065	U	0.065	0.069	U	0.069	0.14	U	0.14	0.23	U	0.23
Split of J117N6	J117X2	2/23/06				-0.0067	U	0.0169	-0.00240	U	0.0196	-0.002	U	0.0443	-0.0217	U	0.0635
DZ A1	J117M3	2/9/06	0.32	U	0.32	0.084	U	0.084	0.098	U	0.098	0.21	U	0.21	0.27	U	0.27
Duplicate of J117M3	J117M6	2/9/06	0.27	U	0.27	0.082	U	0.082	0.095	U	0.095	0.22	U	0.22	0.27	U	0.27
Split of J117M3	J117X0	2/9/06				-0.0017	U	0.0172	0.000753	U	0.0161	0.195	U	0.0590	0.00514	U	0.0555
DZ A2	J117M4	2/9/06	0.28	U	0.28	0.273		0.084	0.16	U	0.16	1.82		0.18	0.30	U	0.30
DZ A3	J117M5	2/9/06	0.10	U	0.10	0.16	U	0.16	0.14	U	0.14	2.10		0.49	0.45	U	0.45
OB A1	J117M8	2/14/06	0.21	U	0.21	0.11	U	0.11	0.10	U	0.10	0.32	U	0.32	0.34	U	0.34
Duplicate of J117M8	J117N2	2/14/06	0.27	U	0.27	0.14	U	0.14	0.15	U	0.15	0.42	U	0.42	0.44	U	0.44
Split of J117M8	J117X1	2/14/06				0.0457		0.0131	0.00359	U	0.0146	0.640		0.0351	0.0478	U	0.0509
OB A2	J117M9	2/14/06	0.29	U	0.29	0.083	U	0.083	0.093	U	0.093	0.19	U	0.19	0.25	U	0.25
OB A3	J117N0	2/14/06	0.20	U	0.20	0.053	U	0.053	0.059	U	0.059	0.14	U	0.14	0.19	U	0.19
OB A4	J117N1	2/14/06	0.31	U	0.31	0.087	U	0.087	0.090	U	0.090	0.20	U	0.20	0.30	U	0.30
Equipment blank	J117M7	2/9/06	0.17	U	0.17	0.083	U	0.083	0.088	U	0.088	0.25	U	0.25	0.30	U	0.30

Note: The following abbreviations apply to all Attachment 1 tables.

Note: Data qualified with J are considered acceptable values.

DZ = deep zone

HEIS = Hanford Environmental Information System

J = estimated

MDA = minimum detectable activity

OB = overburden

PQL = practical quantitation limit

Q = qualifier

SZ = shallow zone

U = undetected

Attachment	1	Sheet No.	1 of 2
Originator	J. M. Capron	Date	05/15/06
Checked	T. M. Blakley	Date	5/15/06
Calc. No.	0100F-CA-V0249	Rev. No.	0

Attachment 1. 116-F-8 Verification Sampling Results.

Sample Location	HEIS Number	Sample Date	Europium-155			Potassium-40			Radium-226			Radium-228			Silver-108m		
			pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA
SZ A1	J117N3	2/23/06	0.26	U	0.26	13.2		0.63	0.465		0.15	0.593		0.45	0.061	U	0.061
SZ A2	J117N4	2/23/06	0.15	U	0.15	9.88		0.63	0.389		0.14	0.620		0.27	0.044	U	0.044
SZ A3	J117N5	2/23/06	0.24	U	0.24	12.0		0.72	0.323		0.13	0.685		0.26	0.045	U	0.045
SZ A4	J117N6	2/23/06	0.18	U	0.18	10.9		0.92	0.266		0.18	0.35	U	0.35	0.051	U	0.051
Duplicate of J117N6	J117N7	2/23/06	0.18	U	0.18	13.6		0.49	0.270		0.12	0.314		0.27	0.046	U	0.046
Split of J117N6	J117X2	2/23/06	0.0183	U	0.0436										0.00278	U	0.0133
DZ A1	J117M3	2/9/06	0.24	U	0.24	14.4		0.95	0.330		0.15	0.885		0.39	0.060	U	0.060
Duplicate of J117M3	J117M6	2/9/06	0.21	U	0.21	10.2		1.0	0.418		0.14	0.891		0.30	0.055	U	0.055
Split of J117M3	J117X0	2/9/06	0.0515	U	0.0471										-0.00079	U	0.0133
DZ A2	J117M4	2/9/06	0.23	U	0.23	10.5		0.79	0.62	U	0.62	0.75	U	0.75	0.059	U	0.059
DZ A3	J117M5	2/9/06	0.33	U	0.33	9.84		1.0	0.27	U	0.27	0.64	U	0.64	0.10	U	0.10
OB A1	J117M8	2/14/06	0.23	U	0.23	9.73		1.1	0.350		0.18	0.47	U	0.47	0.074	U	0.074
Duplicate of J117M8	J117N2	2/14/06	0.29	U	0.29	11.3		1.0	0.394		0.22	0.63	U	0.63	0.097	U	0.097
Split of J117M8	J117X1	2/14/06	0.0349	U	0.0398										0.00017	U	0.0105
OB A2	J117M9	2/14/06	0.23	U	0.23	14.4		0.92	0.414		0.16	0.546		0.35	0.052	U	0.052
OB A3	J117N0	2/14/06	0.16	U	0.16	4.10		0.60	0.151		0.11	0.45	U	0.45	0.036	U	0.036
OB A4	J117N1	2/14/06	0.25	U	0.25	13.8		0.85	0.408		0.18	0.700		0.34	0.061	U	0.061
Equipment blank	J117M7	2/9/06	0.18	U	0.18	4.30		0.62	0.17	U	0.17	0.39	U	0.39	0.061	U	0.061

Sample Location	HEIS Number	Sample Date	Thorium-228			Thorium-232			Uranium-235			Uranium-238			Hexavalent Chromium		
			pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA	pCi/g	Q	MDA	mg/kg	Q	PQL
SZ A1	J117N3	2/23/06	0.516		0.11	0.593		0.45	0.36	U	0.36	12	U	12	0.22	U	0.22
SZ A2	J117N4	2/23/06	0.510		0.12	0.620		0.27	0.24	U	0.24	10	U	10	0.20	U	0.20
SZ A3	J117N5	2/23/06	0.506		0.068	0.685		0.26	0.25	U	0.25	8.7	U	8.7	0.26		0.21
SZ A4	J117N6	2/23/06	0.402		0.12	0.35	U	0.35	0.28	U	0.28	11	U	11	0.35		0.20
Duplicate of J117N6	J117N7	2/23/06	0.360		0.11	0.314		0.27	0.26	U	0.26	7.9	U	7.9	0.21		0.20
Split of J117N6	J117X2	2/23/06													0.350	U	0.350
DZ A1	J117M3	2/9/06	0.704		0.14	0.885		0.39	0.30	U	0.30	11	U	11	0.21	U	0.21
Duplicate of J117M3	J117M6	2/9/06	0.500		0.13	0.891		0.30	0.27	U	0.27	9.0	U	9.0	0.22	U	0.22
Split of J117M3	J117X0	2/9/06													0.350	U	0.350
DZ A2	J117M4	2/9/06	0.466		0.097	0.75	U	0.75	0.26	U	0.26	11	U	11	0.22	U	0.22
DZ A3	J117M5	2/9/06	0.849		0.21	0.64	U	0.64	0.46	U	0.46	17	U	17	0.21	U	0.21
OB A1	J117M8	2/14/06	0.666	J	0.15	0.47	U	0.47	0.35	U	0.35	12	U	12	0.20	U	0.20
Duplicate of J117M8	J117N2	2/14/06	0.744	J	0.20	0.63	U	0.63	0.43	U	0.43	16	U	16	0.25		0.21
Split of J117M8	J117X1	2/14/06													0.350	U	0.350
OB A2	J117M9	2/14/06	0.506		0.10	0.546		0.35	0.29	U	0.29	10	U	10	0.22		0.20
OB A3	J117N0	2/14/06	0.399	J	0.093	0.45	U	0.45	0.19	U	0.19	7.3	U	7.3	0.21	U	0.21
OB A4	J117N1	2/14/06	0.401	J	0.15	0.700		0.34	0.30	U	0.30	11	U	11	0.22		0.20
Equipment blank	J117M7	2/9/06	0.12	U	0.12	0.39	U	0.39	0.28	U	0.28	10	U	10	0.20	U	0.20

Attachment	1	Sheet No.	2 of 2
Originator	J. M. Capron	Date	05/15/06
Checked	T. M. Blakley	Date	
Calc. No.	0100F-CA-V0249	Rev. No.	0

CALCULATION COVER SHEET

Project Title 100-F Area Field Remediation **Job No.** 14655
Area 100-F Area
Discipline Environmental ***Calc. No.** 0100F-CA-V0270
Subject 116-F-8 Waste Site Cleanup Verification RESRAD Calculation
Computer Program RESRAD **Program No.** Version 6.3

The attached calculations have been generated to document compliance with established cleanup levels.
These documents 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 – 6 pg Attm. 1 - 1 pg Attm. 2 - 19 pg Attm. 3 - 21 pg Attm. 4 - 10 pg Total – 58 pages	M.W. Perrott 8/22/06	S. W. Clark 8/22/06	T. M. Blakley 8/24/06	L.M. Dittmer 8/29/06	8/29/06
SUMMARY OF REVISION						

*Obtain Calc. No. from DIS

DE01-437.03 (12/09/2004)

Washington Closure Hanford CALCULATION SHEET

Originator:	M.W. Perrott	Date:	8/22/06	Calc. No.:	0100F-CA-V0270	Rev.:	0
Project:	Sample Design and Cleanup Verification	Job No:	14655	Checked:	S. W. Clark	Date:	8/22/06
Subject:	116-F-8 Waste Site Cleanup Verification RESRAD Calculation					Sheet No. 1 of 6	

PURPOSE:

Calculate the soil and groundwater concentrations, dose, and risk contributions from remaining radionuclide contaminants in the vadose zone at the 116-F-8, 1904-F Outfall Structure site over a period of 1,000 years.

GIVEN/REFERENCES:

1) Maximum values from *116-F-8 Waste Site Cleanup Verification 95% UCL Calculations,* Calculation No. 0100F-CA-V0249, Rev. 0, Washington Closure Hanford, Richland, Washington.
2) Field Logbooks EFL-1174, EFL-1174-1 Washington Closure Hanford, Richland, Washington.
3) *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP), DOE/RL-96-17, Rev. 5, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
3) Radioactive and nonradioactive contaminants of concern from the *100 Area Remedial Action Sampling and Analysis Plan* (100 Area SAP), DOE/RL-96-22, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington. For the purpose of these RESRAD calculations, the radioactive contaminants of concern (COCs) are cesium-137, cobalt-60, europium-152, europium-154, and europium-154. For the purpose of these RESRAD calculations, there are no nonradionuclide contaminants of concern.
4) RESidual RADioactivity (RESRAD) computer code, version 6.3, 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.
5) Sample design data from the *116-F-8 Shallow, Deep Zone and Overburden Sampling Plan*, Calculation No. 0100F-CA-V0242, Rev. 0, Washington Closure Hanford, Richland, Washington.
6) For the purpose of these RESRAD calculations, the sampling area calculated for the 116-F-8 Waste site Deep Zone excavation is 1094.6 m^2, which was used for all RESRAD calculations.

Washington Closure Hanford		CALCULATION SHEET					
Originator:	M.W. Perrott	Date:	8/22/06	Calc. No.:	0100F-CA-V0270	Rev.:	0
Project:	Sample Design and Cleanup Verification	Job No:	14655	Checked:	S. W. Clark	Date:	8/22/06
Subject:	116-F-8 Waste Site Cleanup Verification RESRAD Calculation					Sheet No. 2 of 6	

SOLUTION:

1) Table 1 shows the waste site parameters used for RESRAD modeling. A sample was collected in the deep zone at the bottom of the excavation, at the groundwater table. Based on the conservative assumption (discussed in the 100 Area RDR/RAWP) that residual contamination levels from the deep zone data set extend uniformly to groundwater, the initial contamination found in the bottom of the excavation has been modeled as extending throughout the deep zone of the 116-F-8 waste site.
2) Table 2 shows the radionuclide activities for each COC. Input factors for each RESRAD run are shown in the "Summary" section of the RESRAD "Mixture Sums and Single Radionuclide Guidelines" printouts in Attachments to this Calculation Summary.
3) The RESRAD modeling for the 116-F-8 waste site indicates that the contaminants of concern will reach maximum concentrations at the water table in year 43, where year 0 is 2006 and year 43 is 2049. The model was run for year 43 and for the default years of 1, 3, 12, 30, 100, 300, and 1000. Twelve years corresponds to the 2018 date of the original 30-year site cleanup schedule in the *Hanford Federal Facility Agreement and Consent Order.*

Table 1. Waste Site Dimensions for RESRAD Modeling

Parameter	Units	Value	Comments
Shallow Zone Cover Depth	m	0	
Area of Deep Zone	m^2	1094.6	Based on post-excavation topography map [a]
Thickness: Shallow Zone	m	4.6	Appendix B of 100 Area RDR/RAWP
Elevation: Ground Surface	m	123.0	NAVD88
Elevation: Excavation Bottom	m	114	NAVD88
Elevation: Groundwater	m	114	NAVD88
Thickness: Deep Zone	m	4.4	Vadose zone thickness minus shallow zone
Length Parallel to Aquifer Flow	m	47.4	Based on Sample Design drawings [a]

[a] from the *116-F-8 Shallow, Deep Zone and Overburden Sampling Plan*, Calculation No. 0100F-CA-V0242, Rev. 0, Washington Closure Hanford, Richland, Washington.

Washington Closure Hanford			CALCULATION SHEET				
Originator:	M.W. Perrott	Date:	8/22/06	Calc. No.:	0100F-CA-V0270	Rev.:	0
Project:	Sample Design and Cleanup Verification	Job No:	14655	Checked:	S. W. Clark	Date:	8/23/06
Subject:	116-F-8 Waste Site Cleanup Verification RESRAD Calculation					Sheet No. 3 of 6	

METHODOLOGY:

1) A run of RESRAD version 6.3 was completed for the deep zone using the radionuclide concentrations shown in Table 2. RESRAD numerical output reports for dose, risk, and concentration for the deep zone are presented in the Attachments to this calculation summary.

Table 2. Maximum Contaminant Concentrations

COCs	Maximum Deep Zone Concentrations (pCi/g)[a]
Cs-137	0.249
Co-60	0.16 U[b]
Eu-152	2.37
Eu-154	0.45 U[b]
Eu-155	0.33 U[b]

[a] Confirmatory sampling data maximum values from *116-F-8 Waste Site Cleanup Verification 95% UCL Calculations,* Calculation No. 0100F-CA-V0249, Rev. 0, Washington Closure Hanford, Richland, Washington.

[b] Value was not input into RESRAD because analyte was not detected in cleanup verification samples.

RESULTS:

1) Radionuclide "All Pathways" Dose Rate: The "all pathways" dose rates are shown in Table 3 and in Figure 1. The maximum predicted "all pathways" dose rate is 5.33E-04 mrem/year in year 43 (ie., calendar year 2049). The primary contributor to the all pathways dose rate is Cs-137 through the water pathway.

Table 3. All Pathway Dose Rate (mrem/yr)

Vadose Zone Horizon	"All Pathways" Dose Contributions in mrem/yr at each time slice (yr)							
	1	3	12	30	43	100	300	1000
Deep Zone	3.15E-05	9.27E-05	3.04E-04	5.02E-04	5.33E-04	3.32E-04	9.71E-06	2.74E-12

2) Radionuclide Excess Cancer Risk: The radionuclide excess lifetime cancer risk results are shown in Table 4 and in Figure 2. The maximum total excess lifetime cancer risk is 1.02E-08 in year 30. The primary contributor to the radionuclide excess lifetime cancer risk is Cs-137 through the water pathway.

Table 4. Radionuclide Excess Lifetime Cancer Risk

Vadose Zone Horizon	Excess Cancer Risk at Each Time Slice (yr)							
	1	3	12	30	43	100	300	1000
Deep Zone	06.57E-09	7.15E-09	9.03E-09	1.02E-08	9.82E-09	5.28E-09	1.43E-10	3.85E-17

Washington Closure Hanford CALCULATION SHEET

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Figure 1: 116-F-8 Dose, All Nuclides Summed, All Pathways Summed

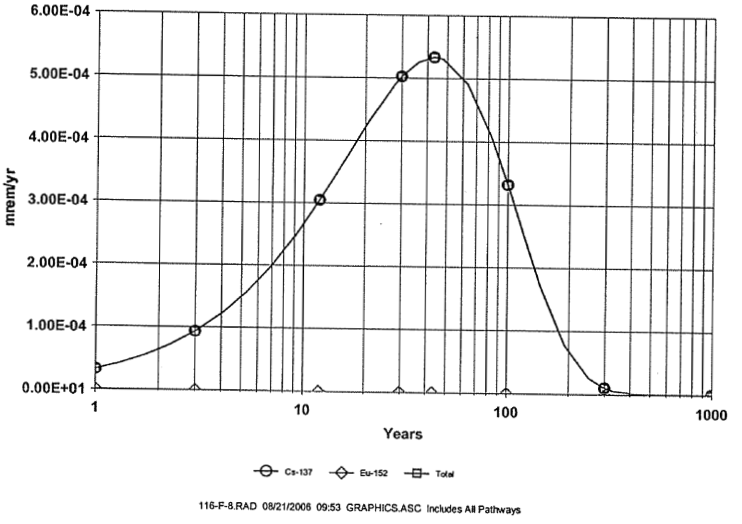
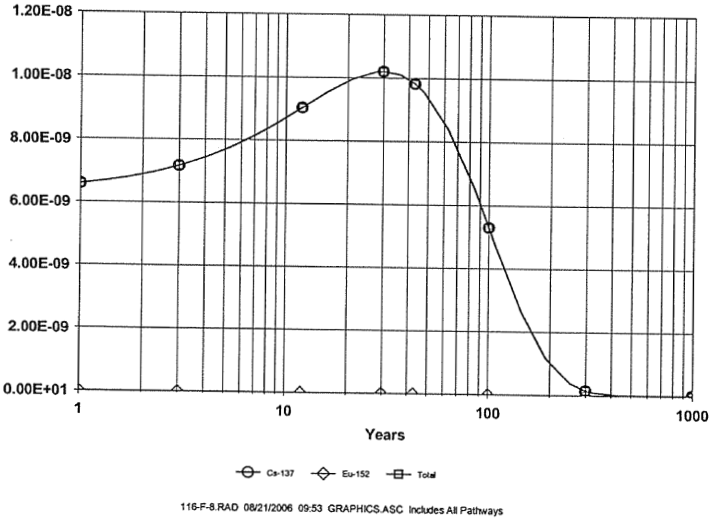


Figure 2: 116-F-8 Excess Cancer Risk, All Nuclides Summed, All Pathways Summed



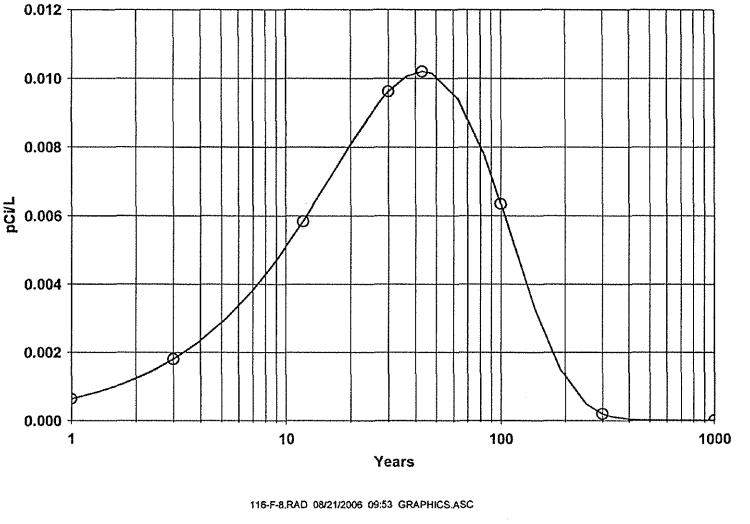
Washington Closure Hanford		CALCULATION SHEET					
Originator:	M.W. Perrott	Date:	8/22/06	Calc. No.:	0100F-CA-V0270	Rev.:	0
Project:	Sample Design and Cleanup Verification	Job No:	14655	Checked:	S. W. Clark	Date:	8/22/06
Subject:	116-F-8 Waste Site Cleanup Verification RESRAD Calculation					Sheet No. 5 of 6	

3) Radionuclide Groundwater Protection: The radionuclide concentrations in groundwater calculated by the RESRAD model are shown in Table 5 and Figure 3. The maximum well water concentration for Cs-137 is in year 43 at 1.02E-02 pCi/year. The RESRAD model predicts that Eu-152 will not affect the groundwater within 1000 years.

Table 5. RESRAD Predicted Radionuclide Groundwater (Well Water) Concentrations

Radio-nuclides	Vadose Zone Horizon	Groundwater Concentrations in pCi/L at Each Time Slice (yr)								RAGs From RDR
		1	3	12	30	43	100	300	1000	
Cs-137	**Deep**	6.26E-04	1.79E-03	5.83E-03	9.60E-03	1.02E-02	6.33E-03	1.85E-04	5.23E-11	60
Eu-152	**Deep**	0	0	0	0	0	0	0	0	200

Figure 3: 116-F-8 Concentration of Cs-137 in Well Water



Washington Closure Hanford CALCULATION SHEET

Originator:	M.W. Perrott	Date:	8/22/06	Calc. No.:	0100F-CA-V0270	Rev.:	0
Project:	Sample Design and Cleanup Verification	Job No:	14655	Checked:	S. W. Clark	Date:	8/22/06
Subject:	116-F-8 Waste Site Cleanup Verification RESRAD Calculation					Sheet No.	6 of 6

CONCLUSIONS:

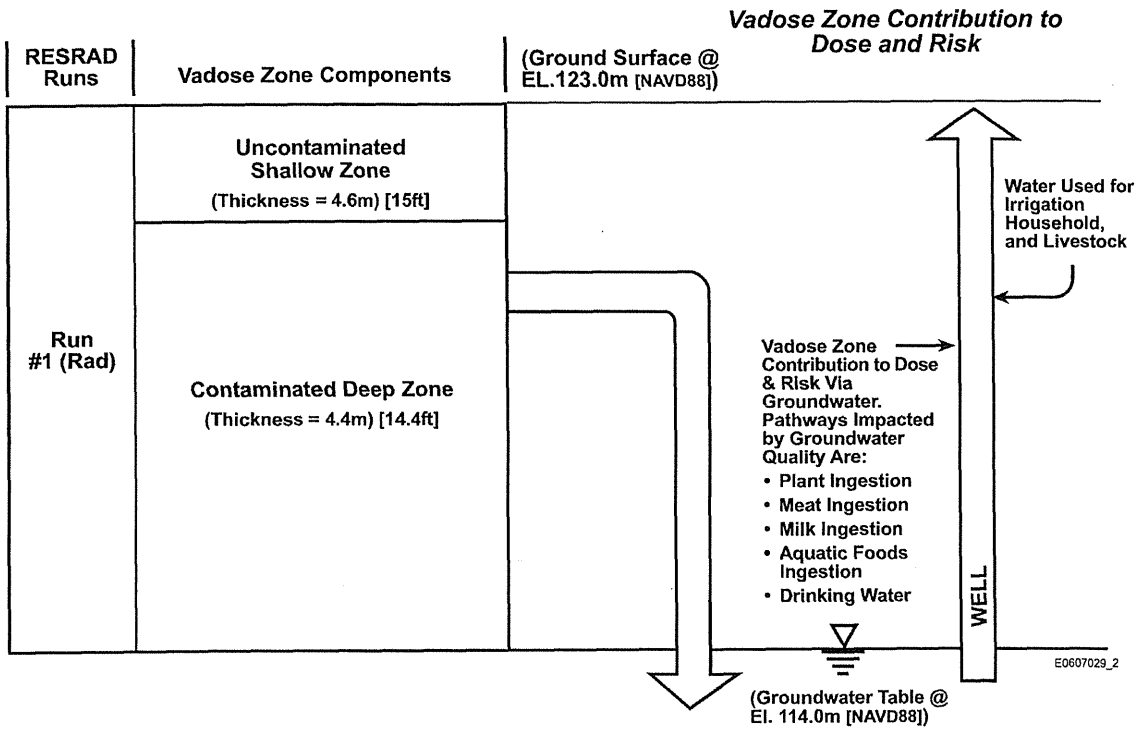
- The maximum all-pathways dose rate for the 116-F-8 deep zone shown in Table 3 is 5.33E-04 mrem/year.
- The maximum total excess lifetime cancer risk for the 116-F-8 deep zone shown in Table 4 is 1.02E-08.
- The primary contributor to the all-pathways dose rate and the total excess lifetime cancer risk at the 116-F-8 site is Cs-137.
- The maximum concentration of Cs-137 in the groundwater is 1.02E-02 pCi/year.
- None of the site COCs are projected to exceed remedial action goals (RAGs).
- Cs-137 is the only radionuclide contaminant predicted to affect groundwater (at concentrations significantly below the individual drinking water dose RAG of 4 mrem/yr). Therefore, it is not necessary to do a MCL calculation to determine that the combined groundwater radionuclide dose is less than 4mrem/yr.

ATTACHMENTS:

1. Graphic showing 116-F-8 Cleanup Verification Model (1 page)
2. RESRAD Output: 116-F-8 Deep Zone Radionuclides, Mixture Sums and Single Radionuclide Guidelines (19 pages)
3. RESRAD Output: 116-F-8 Deep Zone Radionuclides, Intake Quantities and Health Risk Factors (21 pages)
4. RESRAD Output: 116-F-8 Deep Zone Radionuclides, Concentration of Radionuclides, (10 pages)

ATTACHMENT 1

116-F-8 Outfall Cleanup Verification Model



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Originator M. W. Perrott MWP Date 8/22/06
Chk'd By S. W. Clark SWC Date 8/22/06
Calc. No. 0100F-CA-V0270 Rev. No. 0

ATTACHMENT 2

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Summary : 116-F-8 Outfall File: 116-F-8.RAD

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Part I: Mixture Sums and Single Radionuclide Guidelines

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Originator M. W. Perrott Date 8/22/06
Chk'd By S. W. Clark Date 8/22/06
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ATTACHMENT 2

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Summary : 116-F-8 Outfall File: 116-F-8.RAD

Dose Conversion Factor (and Related) Parameter Summary
File: HEAST 2001 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Cs-137+D	3.190E-05	3.190E-05	DCF2(1)
B-1	Eu-152	2.210E-04	2.210E-04	DCF2(2)
B-1	Gd-152	2.430E-01	2.430E-01	DCF2(4)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Cs-137+D	5.000E-05	5.000E-05	DCF3(1)
D-1	Eu-152	6.480E-06	6.480E-06	DCF3(2)
D-1	Gd-152	1.610E-04	1.610E-04	DCF3(4)
D-34	Food transfer factors:			
D-34	Cs-137+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(1,1)
D-34	Cs-137+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-02	3.000E-02	RTF(1,2)
D-34	Cs-137+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,3)
D-34	Eu-152 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(2,1)
D-34	Eu-152 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-03	2.000E-03	RTF(2,2)
D-34	Eu-152 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-05	5.000E-05	RTF(2,3)
D-34	Gd-152 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(4,1)
D-34	Gd-152 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-03	2.000E-03	RTF(4,2)
D-34	Gd-152 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(4,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Cs-137+D , fish	2.000E+03	2.000E+03	BIOFAC(1,1)
D-5	Cs-137+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)
D-5	Eu-152 , fish	5.000E+01	5.000E+01	BIOFAC(2,1)
D-5	Eu-152 , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(2,2)
D-5	Gd-152 , fish	2.500E+01	2.500E+01	BIOFAC(4,1)
D-5	Gd-152 , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(4,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

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Summary : 116-F-8 Outfall File: 116-F-8.RAD

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.095E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	4.400E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	4.740E+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)	1.200E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	4.300E+01	1.000E+02	---	T(6)
R011	Times for calculations (yr)	1.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	3.000E+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): Cs-137	2.490E-01	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Eu-152	2.370E+00	0.000E+00	---	S1(2)
R012	Concentration in groundwater (pCi/L): Cs-137	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Eu-152	not used	0.000E+00	---	W1(2)
R013	Cover depth (m)	4.600E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.600E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	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)	1.000E-03	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	4.050E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	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)	2.500E+02	2.500E+02	---	UW

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Summary : 116-F-8 Outfall File: 116-F-8.RAD

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Number of unsaturated zone strata	0	1	---	NS
R016	Distribution coefficients for Cs-137				
R016	Contaminated zone (cm**3/g)	5.000E+01	4.600E+03	---	DCNUCC(1)
R016	Saturated zone (cm**3/g)	5.000E+01	4.600E+03	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.265E-04	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Eu-152				
R016	Contaminated zone (cm**3/g)	2.000E+02	-1.000E+00	---	DCNUCC(2)
R016	Saturated zone (cm**3/g)	2.000E+02	-1.000E+00	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	5.673E-05	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for daughter Gd-152				
R016	Contaminated zone (cm**3/g)	-1.000E+00	-1.000E+00	8.249E+02	DCNUCC(4)
R016	Saturated zone (cm**3/g)	-1.000E+00	-1.000E+00	8.249E+02	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.376E-05	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	6.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.000E-01	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)

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Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
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)	1.100E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	2.700E+00	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	1.000E+02	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	3.600E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	1.970E+01	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	7.300E+01	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	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	5.000E-01	5.000E-01	---	FR9
R018	Contamination fraction of plant food	-1	-1	0.500E+00	FPLANT
R018	Contamination fraction of meat	-1	-1	0.547E-01	FMEAT
R018	Contamination fraction of milk	-1	-1	0.547E-01	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	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	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)

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Summary : 116-F-8 Outfall File: 116-F-8.RAD

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	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
C14	DCF correction factor for gaseous forms of C14	not used	0.000E+00	---	CO2F
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
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

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Summary : 116-F-8 Outfall File: 116-F-8.RAD

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
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	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

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Summary : 116-F-8 Outfall File: 116-F-8.RAD

Contaminated Zone Dimensions
Area: 1094.63 square meters
Thickness: 4.40 meters
Cover Depth: 4.60 meters

Initial Soil Concentrations, pCi/g
Cs-137 2.490E-01
Eu-152 2.370E+00

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)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.200E+01	3.000E+01	4.300E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	0.000E+00	3.147E-05	9.268E-05	3.041E-04	5.022E-04	5.330E-04	3.315E-04	9.710E-06	2.737E-12
M(t):	0.000E+00	2.098E-06	6.179E-06	2.027E-05	3.348E-05	3.553E-05	2.210E-05	6.473E-07	1.825E-13

Maximum TDOSE(t): 5.330E-04 mrem/yr at t = 43.24 ñ 0.09 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.324E+01 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.
Cs-137	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
Eu-152	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.324E+01 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.
Cs-137	3.718E-04	0.6975	9.231E-05	0.1732	0.000E+00	0.0000	4.148E-05	0.0778	1.547E-05	0.0290	1.197E-05	0.0224	5.330E-04	1.0000
Eu-152	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	3.718E-04	0.6975	9.231E-05	0.1732	0.000E+00	0.0000	4.148E-05	0.0778	1.547E-05	0.0290	1.197E-05	0.0224	5.330E-04	1.0000

*Sum of all water independent and dependent pathways.

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ATTACHMENT 2

1RESRAD, Version 6.3 T« Limit = 180 days 08/21/2006 09:53 Page 9
Summary : 116-F-8 Outfall File: 116-F-8.RAD

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

Radio-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.
Cs-137	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
Eu-152	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

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

Radio-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.
Cs-137	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
Eu-152	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.

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ATTACHMENT 2

1RESRAD, Version 6.3 T« Limit = 180 days 08/21/2006 09:53 Page 10
Summary : 116-F-8 Outfall File: 116-F-8.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.
Cs-137	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
Eu-152	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.
Cs-137	2.269E-05	0.7212	5.390E-06	0.1713	0.000E+00	0.0000	2.301E-06	0.0731	5.264E-07	0.0167	5.572E-07	0.0177	3.147E-05	1.0000
Eu-152	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	2.269E-05	0.7212	5.390E-06	0.1713	0.000E+00	0.0000	2.301E-06	0.0731	5.264E-07	0.0167	5.572E-07	0.0177	3.147E-05	1.0000

0*Sum of all water independent and dependent pathways.

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1RESRAD, Version 6.3 T« Limit = 180 days 08/21/2006 09:53 Page 11
Summary : 116-F-8 Outfall File: 116-F-8.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.
Cs-137	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
Eu-152	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.
Cs-137	6.532E-05	0.7048	1.600E-05	0.1726	0.000E+00	0.0000	7.078E-06	0.0764	2.338E-06	0.0252	1.945E-06	0.0210	9.268E-05	1.0000
Eu-152	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	6.532E-05	0.7048	1.600E-05	0.1726	0.000E+00	0.0000	7.078E-06	0.0764	2.338E-06	0.0252	1.945E-06	0.0210	9.268E-05	1.0000

0*Sum of all water independent and dependent pathways.

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1RESRAD, Version 6.3 T« Limit = 180 days 08/21/2006 09:53 Page 12
Summary : 116-F-8 Outfall File: 116-F-8.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 = 1.200E+01 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.
Cs-137	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
Eu-152	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 = 1.200E+01 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.
Cs-137	2.125E-04	0.6989	5.263E-05	0.1731	0.000E+00	0.0000	2.358E-05	0.0775	8.605E-06	0.0283	6.741E-06	0.0222	3.041E-04	1.0000
Eu-152	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	2.125E-04	0.6989	5.263E-05	0.1731	0.000E+00	0.0000	2.358E-05	0.0775	8.605E-06	0.0283	6.741E-06	0.0222	3.041E-04	1.0000

0*Sum of all water independent and dependent pathways.

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1RESRAD, Version 6.3 T« Limit = 180 days 08/21/2006 09:53 Page 13
Summary : 116-F-8 Outfall File: 116-F-8.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-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.
Cs-137	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
Eu-152	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-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.
Cs-137	3.504E-04	0.6978	8.696E-05	0.1732	0.000E+00	0.0000	3.906E-05	0.0778	1.452E-05	0.0289	1.125E-05	0.0224	5.022E-04	1.0000
Eu-152	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	3.504E-04	0.6978	8.696E-05	0.1732	0.000E+00	0.0000	3.906E-05	0.0778	1.452E-05	0.0289	1.125E-05	0.0224	5.022E-04	1.0000

*Sum of all water independent and dependent pathways.

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1RESRAD, Version 6.3 T« Limit = 180 days 08/21/2006 09:53 Page 14
Summary : 116-F-8 Outfall File: 116-F-8.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.300E+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.
Cs-137	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
Eu-152	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.300E+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.
Cs-137	3.718E-04	0.6975	9.230E-05	0.1732	0.000E+00	0.0000	4.148E-05	0.0778	1.547E-05	0.0290	1.197E-05	0.0224	5.330E-04	1.0000
Eu-152	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	3.718E-04	0.6975	9.230E-05	0.1732	0.000E+00	0.0000	4.148E-05	0.0778	1.547E-05	0.0290	1.197E-05	0.0224	5.330E-04	1.0000

0*Sum of all water independent and dependent pathways.

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1RESRAD, Version 6.3 T« Limit = 180 days 08/21/2006 09:53 Page 15
Summary : 116-F-8 Outfall File: 116-F-8.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-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.
Cs-137	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
Eu-152	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-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.
Cs-137	2.311E-04	0.6972	5.742E-05	0.1732	0.000E+00	0.0000	2.582E-05	0.0779	9.675E-06	0.0292	7.462E-06	0.0225	3.315E-04	1.0000
Eu-152	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	2.311E-04	0.6972	5.742E-05	0.1732	0.000E+00	0.0000	2.582E-05	0.0779	9.675E-06	0.0292	7.462E-06	0.0225	3.315E-04	1.0000

*Sum of all water independent and dependent pathways.

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1RESRAD, Version 6.3 T« Limit = 180 days 08/21/2006 09:53 Page 16
Summary : 116-F-8 Outfall File: 116-F-8.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.
Cs-137	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
Eu-152	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.
Cs-137	6.768E-06	0.6971	1.682E-06	0.1732	0.000E+00	0.0000	7.566E-07	0.0779	2.842E-07	0.0293	2.189E-07	0.0225	9.710E-06	1.0000
Eu-152	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	6.768E-06	0.6971	1.682E-06	0.1732	0.000E+00	0.0000	7.566E-07	0.0779	2.842E-07	0.0293	2.189E-07	0.0225	9.710E-06	1.0000

*Sum of all water independent and dependent pathways.

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Summary : 116-F-8 Outfall File: 116-F-8.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
0 Water Independent Pathways (Inhalation excludes radon)

0 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.
Cs-137	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
Eu-152	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
0 Water Dependent Pathways

0 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.
Cs-137	1.908E-12	0.6970	4.741E-13	0.1732	0.000E+00	0.0000	2.133E-13	0.0779	8.022E-14	0.0293	6.174E-14	0.0226	2.737E-12	1.0000
Eu-152	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	1.908E-12	0.6970	4.741E-13	0.1732	0.000E+00	0.0000	2.133E-13	0.0779	8.022E-14	0.0293	6.174E-14	0.0226	2.737E-12	1.0000

0*Sum of all water independent and dependent pathways.

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Summary : 116-F-8 Outfall File: 116-F-8.RAD

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

0 Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.200E+01	3.000E+01	4.300E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137+D	Cs-137+D	1.000E+00	0.000E+00	1.264E-04	3.722E-04	1.221E-03	2.017E-03	2.141E-03	1.331E-03	3.900E-05	1.099E-11
0Eu-152	Eu-152	7.208E-01	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
0Eu-152	Eu-152	2.792E-01	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
Eu-152	Gd-152	2.792E-01	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
Eu-152	äDSR(j)		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

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

ONuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.200E+01	3.000E+01	4.300E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	*8.704E+13	1.187E+05	4.030E+04	1.228E+04	7.437E+03	7.007E+03	1.127E+04	3.847E+05	1.365E+12
Eu-152	*1.765E+14	*1.765E+14	*1.765E+14	*1.765E+14	*1.765E+14	*1.765E+14	*1.765E+14	*1.765E+14	*1.765E+14

*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 = 43.24 ñ 0.09 years

ONuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin) (pCi/g)	G(i,tmin) (pCi/g)	DSR(i,tmax) (pCi/g)	G(i,tmax) (pCi/g)
Cs-137	2.490E-01	43.24 ñ 0.09	2.141E-03	7.007E+03	2.141E-03	7.007E+03
Eu-152	2.370E+00	0.000E+00	0.000E+00	*1.765E+14	0.000E+00	*1.765E+14

*At specific activity limit

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Summary : 116-F-8 Outfall File: 116-F-8.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	1.200E+01	3.000E+01	4.300E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00		0.000E+00	3.147E-05	9.268E-05	3.041E-04	5.022E-04	5.330E-04	3.315E-04	9.710E-06	2.737E-12
0Eu-152	Eu-152	7.208E-01		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
Eu-152	Eu-152	2.792E-01		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
Eu-152	äDOSE(j)			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
0Gd-152	Eu-152	2.792E-01		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

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	1.200E+01	3.000E+01	4.300E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00		2.490E-01	2.433E-01	2.322E-01	1.882E-01	1.237E-01	9.130E-02	2.415E-02	2.272E-04	1.834E-11
0Eu-152	Eu-152	7.208E-01		1.708E+00	1.622E+00	1.461E+00	9.147E-01	3.584E-01	1.822E-01	9.372E-03	2.820E-07	4.217E-23
Eu-152	Eu-152	2.792E-01		6.617E-01	6.281E-01	5.660E-01	3.543E-01	1.388E-01	7.056E-02	3.630E-03	1.092E-07	1.634E-23
Eu-152	äS(j):			2.370E+00	2.250E+00	2.027E+00	1.269E+00	4.972E-01	2.527E-01	1.300E-02	3.913E-07	5.851E-23
0Gd-152	Eu-152	2.792E-01		0.000E+00	4.138E-15	1.180E-14	3.790E-14	6.445E-14	7.285E-14	8.104E-14	8.127E-14	8.049E-14

THF(i) is the thread fraction of the parent nuclide.
ORESCALC.EXE execution time = 0.67 seconds

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APPENDIX B

DATA QUALITY ASSESSMENT

DATA QUALITY ASSESSMENT FOR THE 116-F-8 AND 100-F-42 WASTE SITES

OVERVIEW

The data quality assessment (DQA) completes the data life cycle (i.e., planning, implementation, and assessment) that was initiated by the data quality objectives process. The DQA includes a review of the field logbook information (WCH 2006a, 2006b) to verify sample location, date, and time. It also involves a scientific and statistical evaluation of the data to determine if they are of the right type, quality, and quantity to support their intended use for closeout decisions.

This DQA was performed in accordance with the site-specific data quality objectives found in the *100 Area Remedial Action Sampling and Analysis Plan* (SAP) (DOE-RL 2005a). The DQA is based on the guidelines presented in *Guidance for Data Quality Assessment* (EPA 2000). Statistical tests used in this DQA were performed as specified in the SAP and the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP) (DOE-RL 2005b).

Prior to performing statistical tests, the field logbooks (WCH 2006a, 2006b), sample design (Appendix A), and sample analytical data are evaluated. A portion of the cleanup verification sample analytical data are validated for compliance requirements (DOE-RL 2005a). Data evaluation is performed to determine if the laboratory carried out all steps required by the SAP and the laboratory contract governing the conduct of analysis and reporting of the data. This evaluation also examines the available laboratory data to determine if an analyte is present or absent in a sample and the degree of overall uncertainty associated with that determination. Data validation is done in accordance with validation procedures (BHI 2000a, 2000b) as part of data evaluation. After data evaluation and validation, the appropriate statistical analyses are performed on the adjusted raw analytical data (Appendix A) to determine statistical values for each contaminant. The cleanup verification sample analytical data are stored in the Environmental Restoration project-specific database prior to archiving in the Hanford Environmental Information System and are included within the 95% upper confidence limit (UCL) calculation brief in Appendix A.

LABORATORY QUALITY MEASURES

All verification samples are subject to laboratory-specific quality assurance (QA) requirements, including instrument procurement, maintenance, calibration, and operation. Additional laboratory quality control (QC) checks are performed, as appropriate, for the analytical method at a rate of one per sample delivery group (SDG), or one in 20, whichever is more frequent. Laboratory internal QC checks include the following:

- Laboratory Contamination. Each analytical batch contains a laboratory (method) blank (material of similar composition as the samples with known/minimal contamination of the analytes of interest) carried through the complete analytical process. The method blank is

used to evaluate false-positive results in samples due to contamination during handling at the laboratory.

- Analytical Accuracy. For most analyses, a known quantity of representative analytes of interest (matrix spike/matrix spike duplicate [MS/MSD]) is added to a separate aliquot of a sample from the analytical batch. The recovery percentage of the added MS is used to evaluate analytical accuracy. For analyses not amenable to MS techniques (e.g., gamma energy analysis) or where analytical recovery is corrected via internal standards (e.g., alpha spectral analyses), accuracy is evaluated from recovery of the QC reference sample (e.g., laboratory control spike or blank spike sample).

- Analytical Precision. Separate aliquots removed from the same sample container (replicate samples) are analyzed for each analytical batch. The replicate sample results (evaluated as relative percent differences [RPDs]) are used to assess analytical precision.

- QC Reference Samples. A QC reference sample is prepared from an independent standard at a concentration other than that used for calibration, but within the calibration range. Reference samples provide an independent check on analytical technique and methodology.

Laboratories are also subject to periodic and random assessments of the laboratory performance, systems, and overall program. These assessments are performed by the Washington Closure Hanford QA group to ensure that the laboratories are performing within laboratory contract requirements.

DATA VALIDATION

After sampling was completed, all of the fixed-base laboratory data from SDG K0224 were validated by a third-party validator to Level C per ENV-1-2.12 "Data Package Validation." Level C validation procedures are specified in *Data Validation Procedure for Radiochemical Analysis* (BHI 2000b) and *Data Validation Procedure for Chemical Analysis* (BHI 2000a).

Use of Level C validation procedures was included in the review of the following items, as appropriate, for each analytical method:

- Sample holding times
- Method blanks
- MS/MSD recovery
- Surrogate recovery
- Sample replicates
- Associated batch laboratory control sample results
- Data package completeness
- Achievement of required (or contractual) detection limits (RDLs).

Data flagged by the validator as estimated (i.e., "J") indicate that the associated concentration is an estimate, but that the data may be used for decision-making purposes. Data flagged as below

detection limits (i.e., "U") indicate the contaminant was analyzed for but not detected, and the concentration is below the minimum detectable activity (MDA) for radionuclides or the practical quantitation limit (PQL) (i.e., reporting limit) for nonradionuclides. For nonradionuclides, nondetects are reported at the PQL. For radionuclides, nondetects report the actual value obtained from analysis (positive or negative but less than the MDA) except for limited analyses where no value can be calculated. In these cases, the MDA is reported. This situation is applicable for sample results that are below detection limits. All other validated results are considered to be accurate within the standard errors associated with the methods.

The adequacy of laboratory QA/QC was evaluated for precision, accuracy, completeness, and RDLs pursuant to the SAP (DOE-RL 2005a). The organization performing the data validation reported that, of the data given formal validation, the laboratory met the standards for performance for precision (±30%), accuracy (±30%), and completeness (>90%). Comparison of the RDL with the respective MDA or PQL is discussed in the following section.

SDG K0224, a validated SDG, contains five samples (J117M8, J117M9, J117N0, J117N1, and J117N2) from the 116-F-8/100-F-42 waste site combined unit. Sample J117N2 is a duplicate of sample J117M8. Samples in SDG K0224 were analyzed for hexavalent chromium and by gamma spectroscopy for radionuclides. A summary of deficiencies noted during validation follows.

- **Radionuclides.** Third-party validation noted no major deficiencies. A minor deficiency was noted in that the RPD for thorium-228 was above the acceptance criteria at 31%. Third-party validation qualified all of the thorium-228 results in SDG K0224 as estimated, with "J" flags. No other deficiencies were found in the radionuclide data and the data are useable for decision-making purposes.

- **Nonradionuclides.** Third-party validation noted no major or minor deficiencies.

LABORATORY DATA EVALUATION

The following paragraphs include a data evaluation of the remaining verification sample SDGs for the 116-F-8/100-F-42 waste site combined unit. Those SDGs are: J00059, J00061, J00063, K0220, and K0237. SDG J00059 consists of one sample, J117X0, and a split sample, J117M6. SDG J00061 consists of one sample, J117X1, and a split sample, J117M8. SDG J00063 consists of one sample, J117X2, and a split sample, J117N6. SDG K0220 consists of five field samples, J117M3 to J117M7, of which J117M7 is the equipment blank and J117M6 is the duplicate of J117M3. SDG K0237 consists of five samples, J117N3 to J117N7, of which J117N7 is a duplicate of J117N6.

The context for assessing the data includes evaluating the sample data using the statistical methodology of the SAP (DOE-RL 2005a) (included in the calculation brief in Appendix A) and a comparison of analytical results to the parameters as specified in the SAP. This section summarizes the results of the comparison and presents an evaluation of the affected data.

Major Deficiencies

Any data anomaly that causes final data to be qualified as rejected (R flagged) is considered a major deficiency. No major deficiencies were identified in the data.

Minor Deficiencies

Sample Holding Times. All of the method-specific holding times were met for all samples in the 116-F-8/100-F-42 data set.

Method Blanks. The method blank is used to evaluate false-positive results in samples due to contamination during handling at the laboratory.

Radionuclides. All of the method blank results in the radionuclide data were within the acceptance criteria.

Nonradionuclides. All of the method blank results in the radionuclide data were within the acceptance criteria.

MS/MSDs Recoveries. Recovery of spiked analytes in the MS/MSD pair is used to evaluate method efficiency and the effect of the matrix on an environmental sample.

Radionuclides. All MS/MSD recoveries for radionuclide analytes were within acceptance criteria.

Nonradionuclides. A lead chromate spike is often used when evaluating insoluble substrates, such as dried paint, for hexavalent chromium. In several of the SDGs, the lead chromate spike recovery was low. This parameter is not usually reported with soil samples and is only commented on here because the laboratory made a similar comment. The insoluble forms of hexavalent chromium are not of primary concern on the Hanford site. The typical matrix spike (soluble) and matrix spike duplicate were within acceptance criteria. The data are useable for the intended purpose.

RDL Comparison. Reported analytical detection levels for nondetected analytes were compared to the RDLs specified in the SAP (DOE-RL 2005a). When detected results were obtained, evaluation of detection limits was not performed. The data validation and supplemental data evaluation noted any analyses in which the detection limit (MDA or PQL) was above the SAP RDLs for nondetected analytes.

Radionuclides. All of the reported MDAs are sufficiently low for decision-making purposes. All values meet the site cleanup criteria as demonstrated in the calculation briefs (Appendix A) and discussed in this remaining sites verification package.

Nonradionuclides. All of the reported method detection limits are less than applicable remedial action goals, and the data are of sufficient quality for decision-making purposes.

Precision and Accuracy Evaluation. Analytical accuracy and precision were evaluated by examination of the RPD of the main, duplicate, and split samples (Appendix A). Only the contaminants of concern (COCs) detected at five times the detection limit (or greater) are used for data analysis with respect to accuracy and precision.

Radionuclides. RPDs for the radionuclide analytes were not calculated because an evaluation of the data shows none of the analytes were detected in both the main and duplicate (or split) sample at more than five times the target detection limit.

Nonradionuclides. RPDs for the nonradionuclide analytes were not calculated because an evaluation of the data shows none of the analytes were detected in both the main and duplicate (or split) sample at more than five times the target detection limit. 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 data are useable for decision-making purposes.

FIELD QUALITY ASSURANCE/QUALITY CONTROL

Field QA/QC measures were used to assess potential sources of error and cross contamination of soil samples that could bias results. Field QA/QC samples listed in the field logbooks (WCH 2006a, 2006b) are summarized in Table B-1. All main and QA/QC sample results are presented in Appendix A.

Field duplicate samples were 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 duplicate samples for each COC. Only analytes with values above five times the detection limits for both the main and duplicate samples are compared. The 95% upper confidence limit (UCL) calculation briefs in Appendix A provide details on duplicate pair evaluation and RPD calculation. The data are suitable for the intended purpose of cleanup verification.

Table B-1. Summary of Field Quality Control Samples.

Equipment Blank	Main Sample	Duplicate	Split
--	J117M8	J117N2	J117X1
--	J117N6	J117N7	J117X2
J117M7	J117M3	J117M6	J117X0

Split samples were collected to provide a relative measure of the degree of variability in the sampling, sample handling, and analytical techniques used by commercial laboratories. The field main and split samples are evaluated by computing the RPD of the split samples for each COC to determine the usability of the verification data. The U.S. Environmental Protection Agency Contract Laboratory Program duplicate sample comparison methodology, *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA 1994), is used as an initial test of the data from the splits. Only analytes that had values above five times the contractual RDL for both the main and split sample were compared. The 95%

UCL calculation brief in Appendix A provides details on split pair RPD calculation. RPDs for the split samples were not calculated because an evaluation of the data shows none of the analytes were detected in both the main and split sample at more than five times the target detection limit.

SUITABILITY OF DATA

The DQA for the 116-F-8 and 100-F-42 waste sites determined that the data are of the right type, quality, and quantity to support site cleanup verification decisions within specified error tolerances. The evaluation verified that the sample design was sufficient for the purpose of clean site verification. All analytical data were found to be acceptable for decision-making purposes.

REFERENCES

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

BHI, 2000b, *Data Validation Procedure for Radiochemical Analysis*, BHI-01433, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 2005a, *100 Area Remedial Action Sampling and Analysis Plan*, DOE/RL-96-22, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2005b, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 5, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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.

EPA, 2000, *Guidance for Data Quality Assessment*, EPA QA/G-9, QA00 Update, U.S. Environmental Protection Agency, Office of Environmental Information, Washington, D.C.

WCH, 2006a, *100-F Area RAWD Sampling*, Logbook EFL-1174, Washington Closure Hanford, Richland, Washington.

WCH, 2006b, *100-F Area RAWD Sampling*, Logbook EFL-1174-1, Washington Closure Hanford, Richland, Washington.