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CVP-2002-00009
Rev. 0

# Cleanup Verification Package for the 116-F-1 Lewis Canal

**Prepared for the U.S. Department of Energy by Bechtel Hanford, Inc.**

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# EXECUTIVE SUMMARY

## E1.0 INTRODUCTION

This cleanup verification package (CVP) documents completion of remedial action for the 116-F-1 Lewis Canal (also referred to as the 116-F-1 site). The 116-F-1 site is located within the 100-FR-1 Operable Unit in the 100-F Area of the Hanford Site in southeastern Washington State. The 1,744-m (5,721-ft)-long, unlined 116-F-1 Lewis Canal was used to dispose of 105-F Reactor cooling water effluent and to carry effluent to the Columbia River primarily during the 1953 Ball 3X Project and during reactor process tube cleaning activities. The head end of the canal is located approximately 160 m (525 ft) west of the 105-F Reactor building. From the head end, the canal leads to the west and bends due north ending at the river. Effluent from the reactor entering the 116-F-1 Lewis Canal at the head end was transported by two 122-cm (48-in.)-diameter pipelines. These pipelines are not part of the 116-F-1 site; remediation of these pipelines (100-F-19:3) is included in another CVP. Water effluent also entered the 116-F-1 Lewis Canal at two locations father north along the canal from the 183-F water treatment facility and from the 182-F raw water reservoir. Feed pipelines associated with these facilities are not part of the 116-F-1 site; remediation of these pipelines (100-F-19:2) is included in another CVP.

Remedial action objectives and goals for the 116-F-1 site were established by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy, Richland Operations Office, in concurrence with the Washington State Department of Ecology. These goals and objectives are documented in the *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (ROD) (EPA 1997) and the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2002).

The selected remedial action for the 116-F-1 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 at the 200 Areas of the Hanford Site, and (3) backfilling the site with clean soil to average adjacent grade elevation. Excavation was driven by remedial action objectives for direct exposure, protection of groundwater, and protection of the Columbia River. For the respective points of compliance, remedial action goals (RAGs) were established to identify radionuclide and nonradionuclide contaminants of concern (COCs). Waste site COCs identified through process knowledge are listed in the *100 Area Remedial Action Sampling and Analysis Plan* (DOE-RL 2001). The COCs for this site consist of the following:

- Carbon-14
- Cesium-137
- Cobalt-60
- Europium-152
- Europium-154
- Arsenic
- Hexavalent chromium.

## E2.0 RESULTS

Site excavation and waste disposal are complete, and the exposed surfaces have been sampled and analyzed to verify attainment of the RAGs. At the completion of remedial action, the total excavation was approximately 24,820 $m^2$ (267,000 $ft^2$) in area with a depth of approximately 4.5 m (14.8 ft). Approximately 77,696 metric tons (70,634 tons) of material from the site were disposed of at the Environmental Restoration Disposal Facility.

Results of the sampling, laboratory analyses, and data evaluations for the 116-F-1 site indicate that all remedial action objectives and goals for direct exposure, protection of groundwater, and protection of the Columbia River have been met (see Table ES-1). The following sections discuss these results.

## Table ES-1. Summary of Cleanup Verification Results for the 116-F-1 Lewis Canal.

| 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 calculated by RESRAD is 5.61 mrem/yr (not accounting for clean backfill). | Yes | a |
| Direct Exposure – Nonradionuclides | 1. Attain individual COC RAGs. | 1. All individual COC concentrations are below the RAGs. | Yes | b |
| Meet Nonradionuclide Risk Requirements | 1. Hazard quotient of <1 for noncarcinogens. | 1. All hazard quotients are below 1. | Yes | b |
| | 2. Cumulative hazard quotient of <1 for noncarcinogens. | 2. Cumulative hazard quotient is $3.8 \times 10^{-3}$. | | b |
| | 3. Excess cancer risk of $<1 \times 10^{-6}$ for individual carcinogens. | 3. Excess cancer risk for individual carcinogens are all less than $1 \times 10^{-6}$. | | b |
| | 4. Attain a total excess cancer risk of $<1 \times 10^{-5}$ for carcinogens. | 4. Total excess cancer risk is $7 \times 10^{-7}$, which is below $1 \times 10^{-5}$. | | b |
| Groundwater/River Protection – Radionuclides | 1. Attain single-COC groundwater and river protection RAGs. | 1. All single-COC groundwater and river RAGs have been attained. | Yes | c |
| | 2. Attain National Primary Drinking Water Standards: 4 mrem/yr (beta/gamma) dose rate to target receptor/organs. | 2. All organ-specific dose rates are below the 4 mrem/yr dose rate limit. | | c |
| | 3. Meet drinking water standards for alpha emitters: the more stringent of 15 pCi/L MCL or 1/25th of the derived concentration guide per DOE Order 5400.5. | 3. There are no alpha-emitting COCs for this site. | | c |
| | 4. Meet total uranium standard of 21.2 pCi/L.[f] | 4. Uranium is not a COC for this site. | | |
| Groundwater/River Protection – Nonradionuclides | 1. Attain individual nonradionuclide groundwater and river cleanup requirements. | 1. All the groundwater and river RAGs have been attained. | Yes | a,b |
| Other Supporting Information | 1. Sample variance calculation (Appendix C). | | | d |
| | 2. Sample location design (Appendix C). | | | e |

[a] *116-F-1 Lewis Canal RESRAD Calculation*, 0100F-CA-V0140, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.
[b] *116-F-1 Lewis Canal Cleanup Verification 95% UCL Calculation*, 0100F-CA-V0138, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.
[c] *116-F-1 Lewis Canal Comparison to Drinking Water Standards (MCL)*, 0100F-CA-V0139, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.
[d] *116-F-1 Lewis Canal Trench Sample Variance*, 0100F-CA-V0150, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.
[e] *Lewis Canal Trench/Overburden Sampling Design*, 0100F-CA-V0154, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.
[f] Uranium limits selected in the ROD and RDR/RAWP were based on 1/25th of the derived concentration guide from DOE Order 5400.5. Since the time of ROD signature, EPA has promulgated a more restrictive maximum contaminant level (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, Bechtel Hanford, Inc., Richland, Washington (BHI 2001).

## E2.1 DIRECT EXPOSURE SOIL CLEANUP STANDARDS

### E2.1.1 Radionuclides

The ROD (EPA 1997), developed in compliance with the "National Oil and Hazardous Substances Pollution Contingency Plan" (40 *Code of Federal Regulations* 300), expresses the RAG for direct exposure to radionuclides in terms of an allowable radiation dose rate above background (i.e., 15 mrem/yr). The total dose rate above background, considering all radionuclide COCs and pathways, was predicted from the RESidual RADioactivity (RESRAD) dose assessment model (ANL 2002).

The results indicate that the maximum dose rate above background from the shallow zone of the site is 5.61 mrem/yr and would occur at present (year 2003); this dose rate decreases to $2.81 \times 10^{-11}$ mrem/yr in 1,000 years. The estimated total dose rate from the shallow zone in the year 2018 is 0.836 mrem/yr. The 2018 date corresponds to the 30-year site cleanup schedule of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1998). For the overburden, the dose rate is largest at present (year 2003), 1.87 mrem/yr, and decreases to $9.05 \times 10^{-17}$ mrem/yr in 1,000 years. The estimated total dose rate from the overburden in the year 2018 is 0.201 mrem/yr. Total dose rate estimates never exceed the direct exposure RAG of 15 mrem/yr above background.

Although the RAG for radionuclides is expressed in terms of radiation dose, the CVP also includes radionuclide excess lifetime cancer risk estimates as additional information. The "National Oil and Hazardous Substances Pollution Contingency Plan" (40 *Code of Federal Regulations* 300) presents a target range for residual risk of $10^{-4}$ to $10^{-6}$. The RESRAD model calculated the total excess cancer risk for radionuclides using the EPA's Health Effects Assessment Summary Tables (HEAST) (dated April 16, 2001, "Update of Radionuclide Carcinogenicity Slope Factors," available on the Internet at www.epa.gov/radiation/heast). Because of radioactive decay, the risk associated with radionuclides decreases over time. Based on RESRAD results, the excess lifetime cancer risk for the site is largest, $2.18 \times 10^{-5}$, at present (year 2003), and decreases to

$4.58 \times 10^{-16}$ in 1,000 years. The estimated excess cancer risk due to radionuclides for the site in 2018 is $9.80 \times 10^{-6}$. For overburden, the estimated excess cancer risk due to radionuclides is largest at present (year 2003), $7.39 \times 10^{-6}$, and decreases to $6.09 \times 10^{-22}$ in 1,000 years. The estimated excess cancer risk due to radionuclides for the overburden in 2018 is $2.04 \times 10^{-6}$.

### E2.1.2 Nonradionuclides

The nonradionuclide COCs are arsenic and hexavalent chromium. All nonradionuclide COC concentrations are below the RAGs for direct exposure.

With respect to noncarcinogenic risk, the individual and cumulative hazard quotients for COCs with noncarcinogenic effects (arsenic and hexavalent chromium) are below the corresponding RAGs (a hazard quotient of 1.0 in both cases). The cumulative hazard quotient for the site is $3.8 \times 10^{-3}$, and the cumulative hazard quotient for the overburden is $1.1 \times 10^{-3}$.

With respect to carcinogenic risk, the nonradionuclide carcinogenic COCs are arsenic and hexavalent chromium. The excess lifetime cancer risk estimates for these individual COCs for the site and the overburden (0 to 4.6 m [15 ft]) are all below the risk limit for individual COCs of $1 \times 10^{-6}$. The total excess lifetime cancer risk estimates for the site and overburden ($7 \times 10^{-7}$ and $2 \times 10^{-7}$, respectively) are also below their corresponding risk limits of $1 \times 10^{-5}$.

## E2.2 PROTECTION OF GROUNDWATER AND THE RIVER

### E2.2.1 Radionuclides

The estimated radionuclide dose rate via the groundwater and river pathways is below the RAG of 4 mrem/yr for beta and gamma emitters. This site does not have alpha-emitting COCs. In summary, all radionuclide RAGs for protection of groundwater and the river have been met.

### E2.2.2 Nonradionuclides

Based on comparison with groundwater and river protection RAGs, cleanup verification results indicate that residual concentrations of nonradionuclide COCs (i.e., arsenic and hexavalent chromium) are protective of groundwater and the river.

## E3.0 WASTE SITE RECLASSIFICATION

The site meets cleanup standards and has been reclassified as "interim closed out" in accordance with the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1998) and the Waste Site Reclassification Guideline TPA-MP-14 (RL-TPA-90-0001) (DOE-RL 1998). A copy of the waste site reclassification form is included as Attachment ES-1.

# Attachment ES-1
# Waste Site Reclassification Form

| | | |
|---|---|---|
| **Date Submitted:** 09/11/2003<br><br>**Originator:** R. A. Carlson<br><br>**Phone:** 372-9632 | **Operable Unit(s):** 100-FR-1<br><br>**Waste Site ID:** 116-F-1 Lewis Canal<br><br>**Type of Reclassification Action:**<br>Rejected ☐<br>Closed Out ☐<br>Interim Closed Out ☒<br>No Action ☐ | **Control Number:** 2003-07<br><br>**Lead Agency:** EPA |

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 of no action, interim closed-out, or closed-out sites will occur at a future date.

**Description of current waste site condition:**

Remedial action at this site has 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 involves (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 at the 200 Area of the Hanford Site, and (3) backfilling the site with clean soil to adjacent grade elevations. The excavation and disposal activities have been completed.

**Basis for reclassification:**

The 116-F-1 Lewis Canal has been remediated to meet the cleanup standards specified in the *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units,* U.S. Environmental Protection Agency, Region 10, Seattle, Washington. Remedial actions were performed so as to allow rural-residential use of shallow zone soils (i.e., surface to 4.6 m [15 ft] deep) and to protect groundwater and the Columbia River. The basis for reclassification is described in detail in the *Cleanup Verification Package for the 116-F-1 Lewis Canal* (CVP-2002-00009), Bechtel Hanford, Inc., Richland, Washington.

| | | |
|---|---|---|
| H. E. Bilson<br>DOE Project Manager | Signature | 9/19/03<br>Date |
| NA<br>Ecology Project Manager | Signature | Date |
| Dennis A. Faulk<br>EPA Project Manager | Signature | 11-5-03<br>Date |

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# ACRONYMS

| | |
|---|---|
| CFR | *Code of Federal Regulations* |
| COC | contaminant of concern |
| CVP | cleanup verification package |
| DQA | data quality assessment |
| EPA | U.S. Environmental Protection Agency |
| ERDF | Environmental Restoration Disposal Facility |
| HEAST | Health Effects Assessment Summary Tables |
| LCS | laboratory control spike |
| MDA | minimum detectable activity |
| MS | matrix spike |
| NaI | sodium iodide |
| PQL | practical quantitation limit |
| QA | quality assurance |
| QC | quality control |
| RAG | remedial action goal |
| RAO | remedial action objective |
| RDR/RAWP | Remedial Design Report/Remedial Action Work Plan |
| RESRAD | RESidual RADioactivity dose assessment model |
| ROD | Record of Decision |
| RPD | relative percent difference |
| SAP | sampling and analysis plan |
| SDG | sample delivery group |
| TDL | target detection limit |
| UCL | upper confidence limit |
| WAC | *Washington Administrative Code* |

# 1.0 INTRODUCTION

## 1.1 PURPOSE

The purpose of this cleanup verification package (CVP) is to document that the 116-F-1 Lewis Canal (herein referred to as the 116-F-1 site) was remediated in accordance with the *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (ROD) (EPA 1997). The ROD provides the U.S. Department of Energy, Richland Operations Office the authority, guide, and objectives to conduct this remedial action. The preferred remedy specified in the ROD (EPA 1997) and conducted for the 116-F-1 site was excavation and disposal of contaminated materials at the Environmental Restoration Disposal Facility (ERDF).

## 1.2 DOCUMENT ORGANIZATION

The cleanup verification evaluation is presented in the following sections:

- Section 2.0 Site Description and Supporting Information
- Section 3.0 Summary of Remedial Action Objectives and Goals
- Section 4.0 Remedial Action Field Activities
- Section 5.0 Cleanup Verification Data Evaluation
- Section 6.0 Evaluation of Remedial Action Goal Attainment
- Section 7.0 Radionuclide Risk Information
- Section 8.0 Statement of Protectiveness
- Section 9.0 References
- Section 10.0 Bibliography.

The main text is supported by the following appendices:

- Appendix A Summary of Verification Soil Sampling and Analytical Results
- Appendix B Data Quality Assessment
- Appendix C RESRAD Input Parameters and Calculation Brief Excerpts.

# 2.0 SITE DESCRIPTION AND SUPPORTING INFORMATION

## 2.1 SITE HISTORY

The 116-F-1 site is located within the 100-FR-1 Operable Unit in the 100-F Area of the Hanford Site in southeastern Washington State. The 1,744-m (5,721-ft)-long, unlined 116-F-1 Lewis Canal was used to dispose of 105-F Reactor cooling water effluent and to carry effluent to the Columbia River, primarily during the 1953 Ball 3X Project and during reactor process tube cleaning activities. The head end of the canal is located

approximately 160 m (525 ft) west of the 105-F Reactor building. From the head end, the canal leads to the west and quickly bends due north ending at the south bank of the Columbia River (Figure 1).

Effluent from the reactor entering the 116-F-1 Lewis Canal at the head end was transported by two 122-cm (48-in.)-diameter pipelines. These pipelines are not part of the 116-F-1 site; remediation of these pipelines (100-F-19:3) is included in another CVP (BHI 2003). Water effluent also entered the 116-F-1 Lewis Canal at two locations farther north along the canal from the 183-F water treatment facility and from the 182-F raw water reservoir. Although the lateral ditches extending toward the 183-F and 182-F facilities are part of the 116-F-1 Lewis Canal site, the feed pipelines associated with these facilities are not a part of the 116-F-1 site; remediation of these pipelines (100-F-19:2) is included in another CVP (BHI 2002a).

## 2.2 SUBSURFACE CONDITIONS

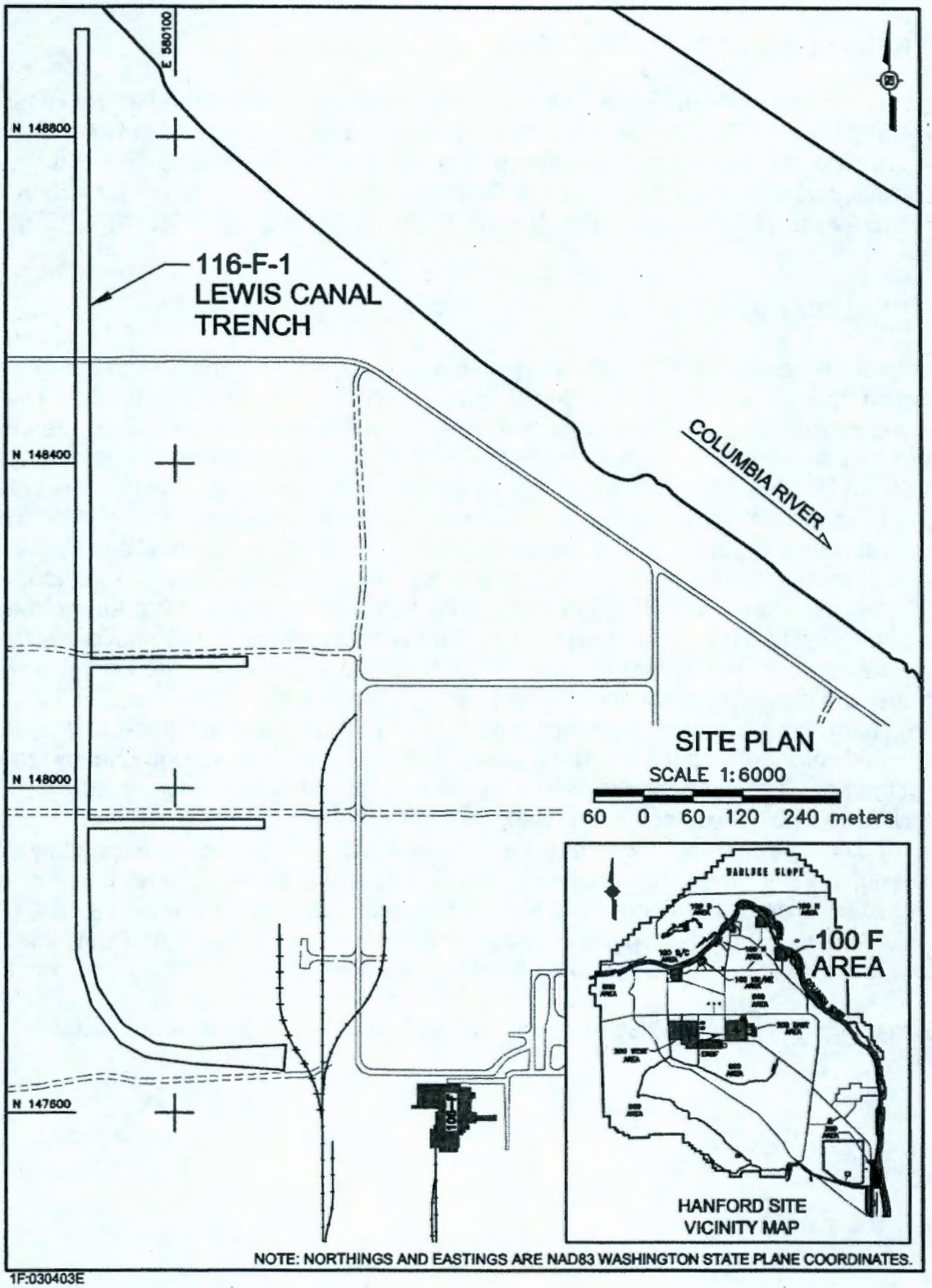
The soil column underlying the waste site and extending to groundwater consists of materials belonging to the Hanford and Ringold Formations. The shallower Hanford formation consists predominantly of medium dense to dense sand and gravel, with varying amounts of silt and cobble. The underlying Ringold Formation consists of dense, well-cemented gravels with sand and silt interbeds. The Hanford/Ringold contact is approximately 12.2 to 18.3 m (40 to 60 ft) below the surface grade level. The long-term groundwater level beneath the site is estimated at El. 114.2 m (374.7 ft) for analysis purposes, based on historical and current information from adjacent groundwater wells. The depth to groundwater is estimated to be 1.9 m (6.2 ft) beneath the floor of the excavation and 6.4 m (21 ft) beneath surface grade level. Groundwater elevations in adjacent wells are influenced by the nearby Columbia River and other factors such as atmospheric pressure.

## 2.3 CONTAMINANTS OF CONCERN

Waste site contaminants of concern (COCs) identified through process knowledge are listed in the *100 Area Remedial Action Sampling and Analysis Plan* (SAP) (DOE-RL 2001). The COCs for this site consist of the following:

- Carbon-14
- Cesium-137
- Cobalt-60
- Europium-152
- Europium-154
- Arsenic
- Hexavalent chromium.

**Figure 1. Hanford Site Map and 116-F-1 Site Plan.**

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# 3.0 SUMMARY OF REMEDIAL ACTION OBJECTIVES AND GOALS

## 3.1 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) for the 116-F-1 site were established in the ROD (EPA 1997). The RAOs are narrative statements that define the extent to which the waste site requires cleanup to protect human health and the environment. For a detailed discussion of the RAOs, see the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP) (DOE-RL 2002) and the ROD (EPA 1997).

## 3.2 REMEDIAL ACTION GOALS

Remedial action goals (RAGs) are the specific numeric goals against which the cleanup verification data are evaluated in order to demonstrate attainment of the RAOs. The RAGs were developed to support a rural-residential exposure scenario. This scenario involves exposures to soils less than 4.6 m (15 ft) deep only. In the rural-residential scenario, an individual is assumed to live for 30 years in a residence built on the waste site and to spend 60% of his or her time indoors, 20% outdoors, and 20% offsite. The scenario assumes a portion of the resident's time is spent in the basement of the home. It further assumes that he or she consumes crops, meat, and milk from plants and animals raised on the waste site, and consumes fish from a pond downgradient from the waste site. Residual (post-cleanup) contaminant concentrations in the shallow zone (i.e., less than 4.6 m [15 ft]) are assumed for the soils in which crops are raised and on which animals providing meat and milk are raised. Water used by the resident for drinking, showering, watering livestock, and for fish production is assumed to be taken from groundwater derived from surface water that has infiltrated through shallow zone soils at the site. The scenario for sites with the high potential to have leached contamination into deeper soil zones assumes institutional controls against uncontrolled drilling or digging into deep zone soils (i.e., below 4.6 m [15 ft]). Because shallow zone soil cleanup criteria have been applied to the entire vadose zone underlying the 116-F-1 excavation, institutional controls against drilling or digging are not required for this site. A more detailed description of the rural-residential scenario, and how it is applied, is provided in the RDR/RAWP (DOE-RL 2002).

The contaminant-specific RAGs that are applicable to the 116-F-1 site are listed in Table 1.

**Table 1. Summary of Remedial Action Goals.**

| COCs | Direct Exposure RAG | Groundwater Protection RAG (pCi/L) | Columbia River Protection RAG (pCi/L) |
|---|---|---|---|
| ***Radionuclides*** | | | |
| Carbon-14 | 15 mrem/yr (cumulative)[a] | 4 mrem/yr (cumulative)[b] | 4 mrem/yr (cumulative)[b] |
| Cesium-137 | | | |
| Cobalt-60 | | | |
| Europium-152 | | | |
| Europium-154 | | | |
| **COCs** | **Direct Exposure RAGs (mg/kg)** | **Soil RAG for Groundwater Protection (mg/kg)** | **Soil RAG for Columbia River Protection (mg/kg)** |
| ***Nonradionuclides*** | | | |
| Hexavalent chromium | 2.1[c,d], 400[e] | 8[f] | 2.0[g] |
| Arsenic | 20[h], 60[e] | 20[h] | 20[h] |

[a]Lookup values that correspond to the 15 mrem/yr dose rate are based on a generic site model and are presented in the RDR/RAWP (DOE-RL 2002).
[b]Lookup values that correspond to individual radionuclide 4 mrem/yr dose rate equivalents for beta and gamma emitters, per National Drinking Water Standards, are presented in the RDR/RAWP (DOE-RL 2002).
[c]*Washington Administrative Code* (WAC) 173-340 Method B carcinogenic cleanup limit.
[d]*Calculation of Hexavalent Chromium Carcinogenic Risk*, 0100X-CA-V0031 (BHI 2000).
[e]WAC 173-340 Method B noncarcinogenic cleanup limit.
[f]Soil RAG based on "100 times groundwater cleanup" rule.
[g]Soil RAG based on 100 times dilution attenuation factor (DAF) times surface water cleanup level.
[h]The WAC 173-340 Method B direct exposure soil value, "100 times groundwater cleanup," and/or the "100 times DAF times surface water protection" soil values were less than Washington State soil background concentrations; therefore, background values are used as the soil RAG.

### 3.2.1 Direct Exposure RAGs

Under the rural-residential scenario, direct exposure RAGs are applicable to soils that are less than 4.6 m (15 ft) below ground surface (shallow zone soils). Direct exposure RAGs are listed in Table 1 and summarized below.

- **Radionuclide COCs:** For radionuclide COCs in the shallow zone (all pathways) and in the deep zone (water-dependent pathways), meet a 15 mrem/yr above background total dose rate (this RAG must be met for 1,000 years).

- **Nonradionuclide COCs:**

  - Hazard quotient of less than 1.0 for noncarcinogenic contaminants.

  - Excess cancer risk of less than $1 \times 10^{-6}$ for individual carcinogenic contaminants.

  - Cumulative excess cancer risk of less than $1 \times 10^{-5}$.

  - Cleanup verification sample results pass the *Washington Administrative Code* (WAC) 173-340 (*Model Toxics Control Act Cleanup Regulation)* three-part test.

### 3.2.2 Groundwater and River Protection

Groundwater and river protection RAGs are applicable to all vadose zone soils (shallow and deep zone soils). For this CVP, river protection and surface water protection are synonymous, since the Columbia River is the only surface water in proximity to the Hanford Site. The term river protection is used throughout this CVP. The groundwater and river protection RAGs are listed in Table 1 and summarized below.

- **Beta- and gamma-emitting radionuclide COCs:** Meet "National Primary Drinking Water Regulations" (40 *Code of Federal Regulations* [CFR] 141.66) dose rate standards (4 mrem/yr total body or organ dose rate) for a period of 1,000 years starting from site cleanup. Meet individual COC RAGs, as applicable.

- **Alpha-emitting radionuclide COCs:** Meet drinking water standards for nonuranium alpha-emitting radionuclides based on the more stringent of 15 pCi/L or 1/25th of the derived concentration guide per DOE Order 5400.5. The maximum contaminant level for uranium is 30 μg/L as promulgated by the U.S. Environmental Protection Agency (EPA) on December 7, 2000 (65 *Federal Register* 76708). For the 116-F-1 site there are no alpha-emitting COCs.

- **Nonradionuclide COCs:** Meet the individual RAGs listed in Table 1 with cleanup verification sample results passing the WAC 173-340 (*Model Toxics Control Act Cleanup Regulation*) three-part test, or demonstrate by site-specific modeling that residual COC levels do not pose an unacceptable threat to groundwater or surface water for 1,000 years (i.e., residual soil levels do not have the potential to exceed groundwater or river water RAGs). The nonradionuclide groundwater and river protection RAGs listed in Table 1 were calculated using the WAC 173-340 "100 times rule" or are soil background concentrations.

## 4.0 REMEDIAL ACTION FIELD ACTIVITIES

### 4.1 EXCAVATION AND DISPOSAL

Remedial action at the 116-F-1 site began in June 2002. Excavation of the site involved removing the overburden materials, buried sludge and debris, the contaminated structure, and underlying contaminated soil. Based on field screening (discussed in Section 4.2), overburden materials identified as potentially clean were placed in stockpiles for potential use as backfill. Contaminated materials were disposed of at ERDF.

In December 2002, excavation was completed for the main excavation. Initial sampling results indicated small areas of contamination in the shallow zone and overburden soils, and additional remediation of a small portion of the site was completed in January of 2003.

Verification sampling activities following the initial and secondary excavation events are discussed in Section 4.4. Pre- and post-remediation topographic maps are shown in Figures 2 and 3, respectively. The general average elevation of the bottom of the excavation was at about 120.6 m (396 ft) upon completion. The excavation was approximately 24,820 $m^2$ (267,000 $ft^2$) in area with a maximum depth of approximately 4.5 m (14.8 ft). Approximately 77,696 metric tons (76,469 tons) of material from the site were disposed of at ERDF.

The two parallel lateral ditches (Figure 1) that carried water effluent from the 183-F water treatment facility and the 182-F raw water reservoir effluent pipeline outlets to the 116-F-1 Lewis Canal did not require remediation and were not excavated. Based on data collected during excavation of the 183-F and 182-F pipelines, test pit data from *Limited Field Investigation Report for the 100-FR-1 Operable Unit* (DOE-RL 1995b), data collected from the 116-F-1 Lewis Canal and ditch intersections, and based on concurrence with the EPA, the lateral ditches did not require excavation or verification sampling. Concurrence is documented in the 100 Area remedial action unit managers' meeting minutes from April 2002 (EPA et al. 2002).

## 4.2 FIELD SCREENING

Field screening was conducted during the site remedial action as specified in the SAP (DOE-RL 2001). Field screening was used to guide the excavation to quickly assess for the presence and level of contamination. Field screening for the 116-F-1 site included using a radiological data mapping system survey, hand-held sodium iodide (NaI) detectors, and gamma energy analyses. The radiological mapping survey is performed over more than 50% of the site excavation surface area. The hand-held NaI detector is used to screen excavated waste material and to screen for potential excavation wall and floor hot spots. Gamma energy analysis was used to support waste characterization and to corroborate the radiological mapping survey and hand-held NaI detector data.

## 4.3 VARIANCE SAMPLING AND ANALYSIS

Variance analysis was performed following field screening. The variance analysis quantifies the variability of residual contamination. This information was used to determine the site-specific number of final cleanup verification samples to be collected.

Variance sampling and testing was performed in December 2002. As specified in the SAP and the instruction guide (DOE-RL 2001, BHI 2002b), variance analysis was performed for the shallow zone decision unit. A total of 168 variance samples were collected from the 116-F-1 site. Variance samples were collected in the locations shown on the sample design calculation brief (Appendix C).

The results of the variance analysis indicated that the number of verification samples to be taken was less than the default number of four; therefore, four final verification samples were collected from each decision subunit.

**Figure 2. Pre-Remediation Topographic Plan.**

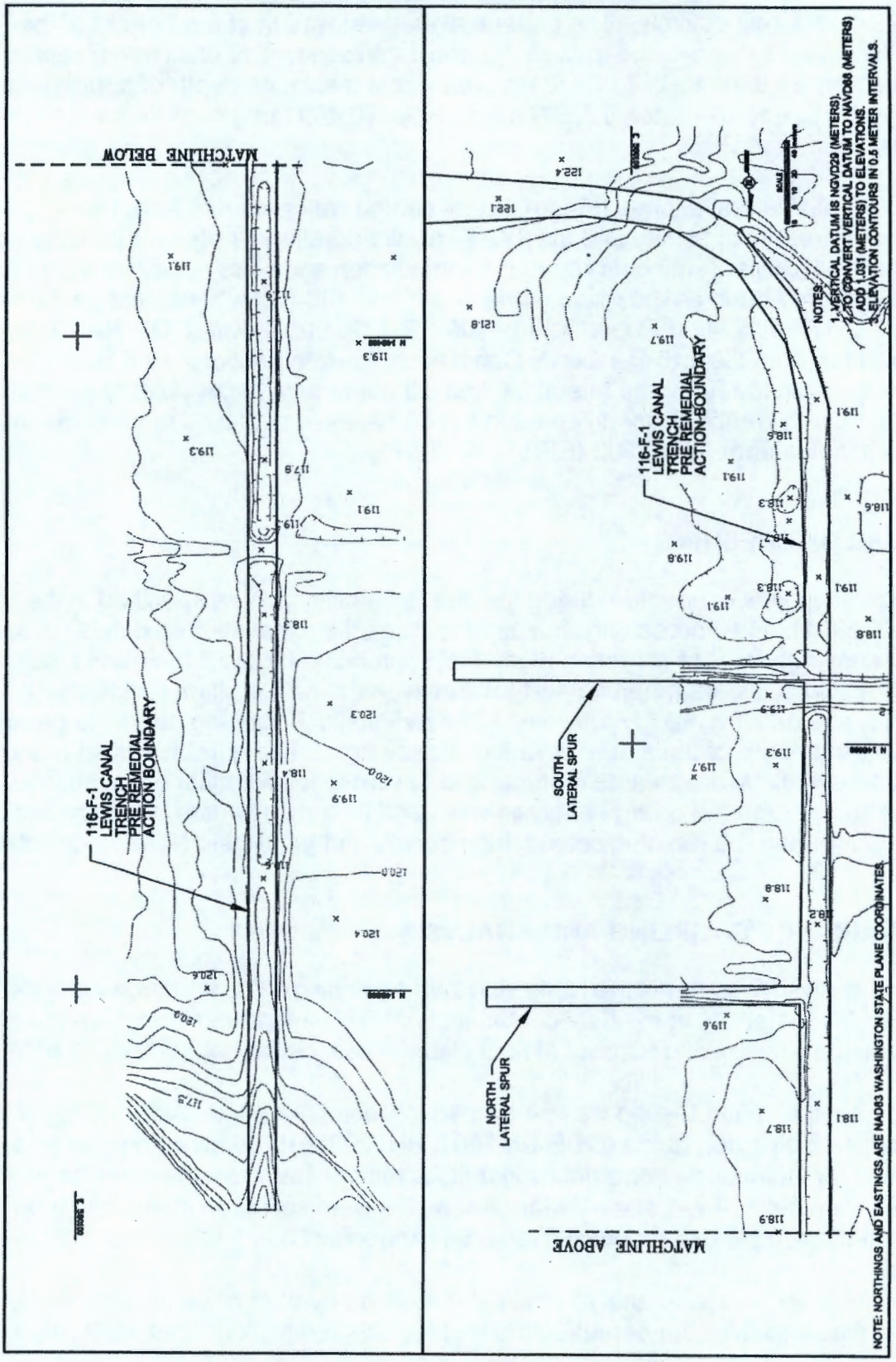
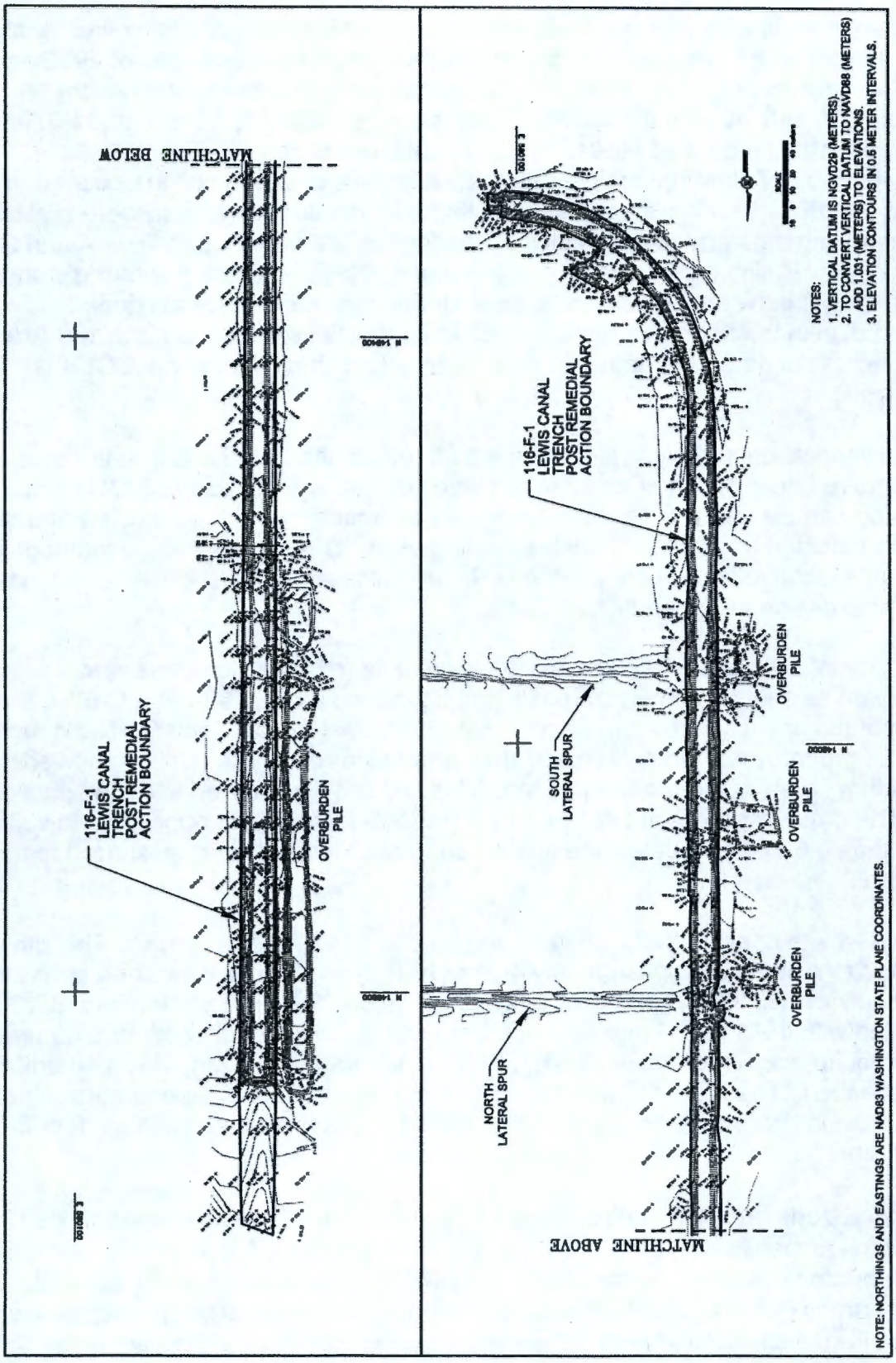


**Figure 3. Post-Remediation Topographic Plan.**



## 4.4 CLEANUP VERIFICATION SAMPLING AND ANALYSIS

Final cleanup verification samples were collected following variance sampling, analysis, and data evaluation. Cleanup verification sampling began in December of 2002 and finished in February of 2003. Initial results indicated small areas of hexavalent chromium contamination in the shallow zone (sample areas A3, A4, B6, and E9) and overburden (sample area A3) soils, and additional remediation was completed in January of 2003. Following additional remedial excavation, resampling occurred in February of 2003. Verification sample results for hexavalent chromium were replaced with resampling data and used in calculations for this site (see Appendices A and C). Profiles of decreasing contaminant concentrations at greater depth (greater distance from former contaminant source) have been generally observed for residual contamination in the bottom of remedial action excavations throughout the 100 Areas. Therefore, use of data from near source or shallower samples for some COCs is conservative.

The final verification samples were submitted to offsite laboratories for analysis using EPA-approved analytical methods, as required per the SAP (DOE-RL 2001). Each verification sample was a composite formed by combining samples collected at four randomly selected nodes within each sampling area. The sample design methodology and sample location figures are presented in the calculation briefs for variance analysis and sample design in Appendix C.

The division of the site excavation into decision units (e.g., shallow zone and overburden) as shown on the sample design figures on pages C-66 and C-67 is a function of the applicable RAGs (Section 3.2, "Remedial Action Goals"). The direct exposure, groundwater protection, and river protection RAGs are applicable to soils within 4.6 m (15 ft) of the ground surface. This soil zone is referred to as the shallow zone. The groundwater protection and river protection RAGs are applicable to soils greater than 4.6 m (15 ft) below the ground surface. This soil zone is referred to as the deep zone.

The 116-F-1 site consisted of a shallow and an overburden decision unit. The site was excavated to a depth of approximately 4.5 m (14.8 ft) with the shallow zone consisting of the excavation sidewalls and floor of the excavation. Because contaminants associated with the 116-F-1 site did not migrate to any significant depth and generally did not require excavation below 4.6 m (15 ft), a separate deep zone decision unit was not established. The more stringent shallow zone criteria (direct exposure, groundwater protection, and river protection) are being applied to all cleanup verification data for the 116-F-1 site.

The shallow zone decision unit contained 7 decision subunits, which were divided into 28 sampling areas (A1-A4, B5-B8, C1, C2, C9, C10, D3-D6, E7-E10, F1-F4, and G5-G8). The overburden decision unit contained two subunits that were divided into eight sampling areas (A1-A4 and B5-B8). One composite cleanup verification sample was collected from each sample area. The sample design for this site is documented in the

sample design calculation brief included in Appendix C. Northing and easting coordinates appearing on the design map are in North American Vertical Datum 1983 (NAVD83) Washington State Plane coordinates. Note that the two east-west parallel ditches are not included on the sample design, because the ditches did not require remediation and verification sampling (see discussion in Section 4.1).

As described in Section 4.3, the required number of composite samples for each decision subunit in the shallow zone was less than the default number of four composite samples specified in the SAP (DOE-RL 2001). Therefore, the default number of four samples were collected from each shallow zone and overburden decision subunits (excluding the quality assurance/quality control samples).

# 5.0 CLEANUP VERIFICATION DATA EVALUATION

This section presents the evaluation and modeling of the 116-F-1 cleanup verification data for comparison with the data quality criteria and RAGs.

## 5.1 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-1 site 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 verified that the sample design was sufficient for the purpose of clean site verification. The cleanup verification sample analytical data are stored in the Hanford Environmental Information System and are summarized in Appendix A. The detailed DQA is presented in Appendix B.

## 5.2 CONTAMINANTS OF CONCERN 95% UPPER CONFIDENCE LIMIT

The primary statistical calculation to support cleanup verification is the 95% upper confidence limit (UCL) on the arithmetic mean of the data. The 95% UCL values for each COC are computed for each decision unit (e.g., for the shallow and deep zones, as appropriate). Prior to calculating the 95% UCL, the individual sample results are reviewed and, as appropriate, adjusted per the SAP (DOE-RL 2001). This process is summarized below.

Verification sampling summary statistics (95% UCL values) are listed in Table 2. Individual sample cleanup verification results are presented in Appendix A.

**Table 2. Cleanup Verification Data.**

| COCs | 95% UCL Statistical Values | | Hanford Site[a] or Washington State[b] Background | Cleanup Verification Data Set[c] | |
|---|---|---|---|---|---|
| | Shallow Zone | Overburden | | Shallow Zone | Overburden |
| ***Radionuclides (pCi/g)[d]*** | | | | | |
| Carbon-14 | 1.47 | 0.633 | N/A[e] | 1.47 | 0.633 |
| Cesium-137 | 0.110 | 0.0258 | 1.1[a] | 0.110 | 0 (<BG) |
| Cobalt-60 | 0.0549 | 0.0242 | 0.008[a] | 0.0549 | 0.0162 |
| Europium-152 | 0.177 | 0.0524 | N/A[e] | 0.177 | 0.0524 |
| Europium-154 | 0.137 | 0.0821 | 0.033[a] | 0.137 | 0.0491 |
| ***Nonradionuclides (mg/kg)[d]*** | | | | | |
| Arsenic | 6.0 | 11.0 | 20[b] | 6.0 | 11.0 |
| Hexavalent chromium | 1.5 | 0.43 | N/A[c] | 1.5 | 0.43 |

[a]Hanford Site background represents the 90th percentile of the lognormal distribution (DOE-RL 1995a).
[b]Washington State soil background (WAC 173-340-740).
[c]The statistical value above background is used as the input value for RESRAD. For overburden, anthropogenic background (DOE-RL 1996) and naturally occurring background is subtracted from all radionuclides. Refer to Appendix C for additional details on determination of statistical values.
[d]Laboratory data including the minimum detectable activity or practical quantitation limit for the individual cleanup verification samples are included in Appendix A and the 95% UCL calculation brief.
[e]A background value for this analyte has not been established.
BG = background
NA = not applicable

- **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), half of the minimum detectable activity is used in the calculation of the 95% UCL.

- **Nonradionuclides:** For data flagged with a "U" (i.e., less than detection), a value equal to one-half the practical quantitation limit is used in the calculation of the 95% UCL, as required by Washington State Department of Ecology regulations (WAC 173-340-740[7][g]).

  For nonradionuclides, if greater than half of the sample results for a given COC are below detection, then the statistical value is set equal to the maximum concentration detected (i.e., versus computing a 95% UCL).

Statistical calculations are presented in the 116-F-1 cleanup verification 95% UCL calculation brief (Appendix C). The columns on the left side of Table 2 are the 95% statistical values before subtraction of background, if appropriate. The columns on the right side of the table present statistical values adjusted for background; it is these values that constitute the cleanup verification data set and are used for RESRAD modeling.

## 5.3 SITE-SPECIFIC CLEANUP VERIFICATION MODEL

The statistical values summarized in Table 2 were evaluated and used to develop a site-specific cleanup verification model. For the 116-F-1 site, the site-specific cleanup verification model assumes the worst case described in the RDR/RAWP (DOE-RL 2002), where the excavation statistical concentrations continue for the deep zone at the same concentrations to groundwater. A schematic cross section of this site-specific cleanup verification model is included in the RESRAD calculation in Appendix C.

## 5.4 RESRAD MODELING

The individual radionuclide cleanup verification statistical values (Table 2) were entered into the RESRAD computer code, Version 6.21 (ANL 2002), to estimate the dose rate and to estimate the impact on groundwater and the river from residual COC concentrations. The direct radiation exposure dose rate to the resident living in his or her basement (rural-residential scenario) was conservatively estimated by substituting (for analysis purposes) a case where the resident is standing on level ground with the soil containing concentrations representative of residual (i.e., post-cleanup) shallow zone soils. This is conservative because it ignores the potential shielding effects of concrete basement walls and any clean backfill between residual soils and the basement walls.

The RESRAD modeling methodologies, results, input values, and the site-specific cleanup verification model are included in the RESRAD calculation brief (Appendix C). The drinking water dose rate calculations that are based on the RESRAD estimated groundwater radionuclide concentrations are shown in the comparison to drinking water standards calculation brief (Appendix C). Specific results from the calculations are discussed in the RAG evaluation section (Section 6.0).

# 6.0 EVALUATION OF REMEDIAL ACTION GOAL ATTAINMENT

This section demonstrates that remedial actions at the 116-F-1 site have achieved the applicable RAGs. Sections 6.1, 6.2, and 6.3 address attainment of direct exposure RAGs, groundwater protection RAGs, and Columbia River protection RAGs, respectively. Section 6.4 documents application of the WAC 173-340 three-part test. This test is required for nonradionuclide COCs only and is based on the most restrictive RAG for each zone.

## 6.1 DIRECT EXPOSURE SOIL REMEDIAL ACTION GOALS ATTAINED

### 6.1.1 Radionuclides

The results of the RESRAD dose rate estimate for the site all-pathways scenarios are presented in Figures 4 and 5. The dose rates represent the dose contributions from soils at relevant time periods. For the shallow zone, the dose rate is largest at present (year 2003), 5.61 mrem/yr, and decreases to $2.81 \times 10^{-11}$ mrem/yr in 1,000 years. The estimated dose rate from the site in 2018 is 0.836 mrem/yr. The 2018 date corresponds to the 30-year site cleanup schedule of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1998). For overburden, the dose rate is largest at present (year 2003), 1.87 mrem/yr, and decreases to $9.05 \times 10^{-17}$ mrem/yr in 1,000 years. The estimated dose rate from overburden in 2018 is 0.201 mrem/yr. All dose rate estimates are less than the 15 mrem/yr RAG. The RESRAD computations are presented in detail in the referenced calculation briefs summarized in Appendix C.

**Figure 4. RESRAD Analysis – All Radionuclides, All-Pathways Dose Rate Estimate for the Shallow Zone.**

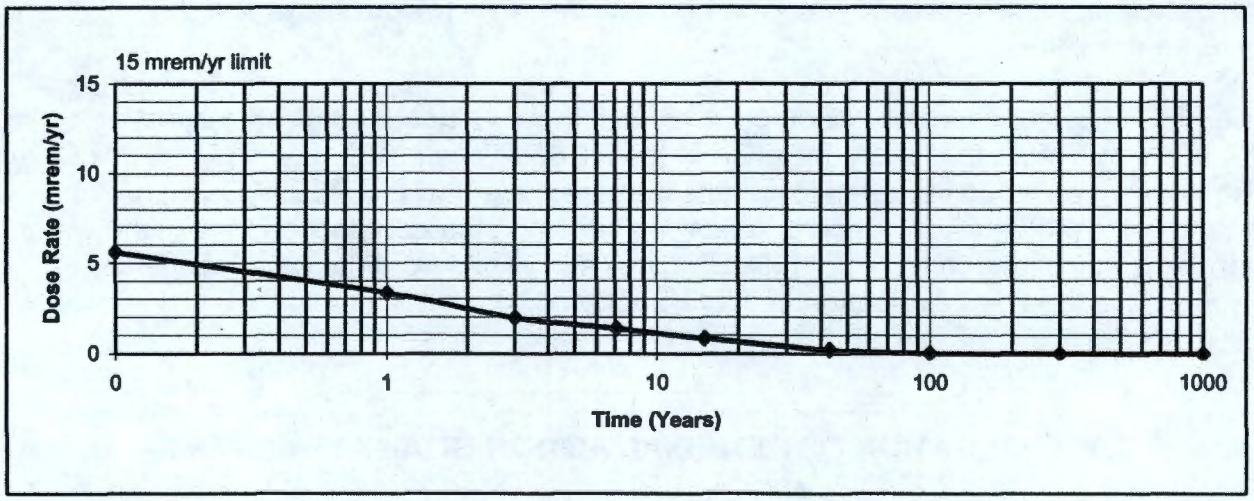
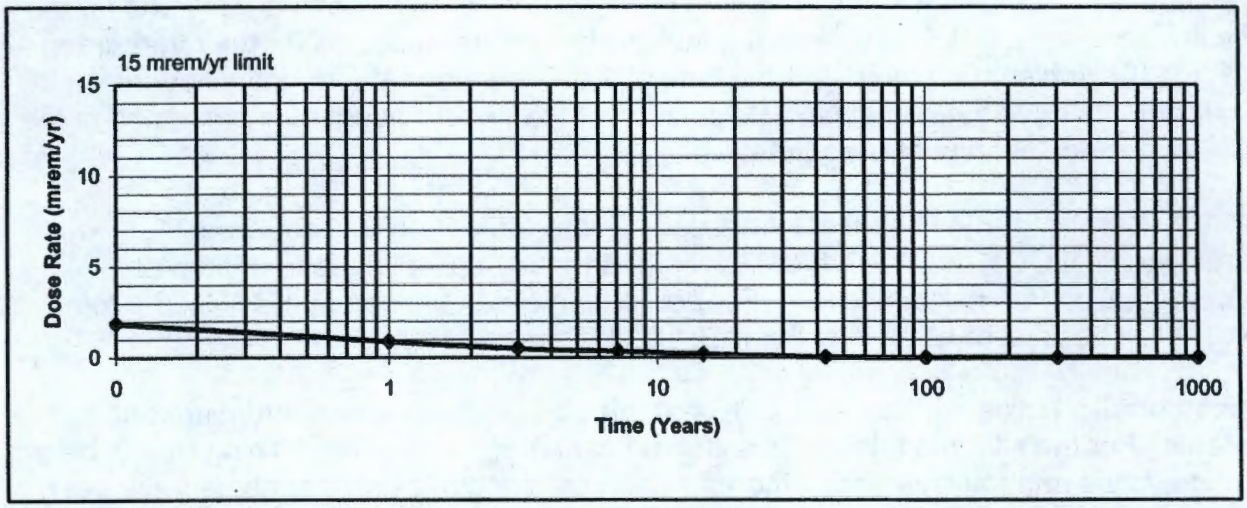


**Figure 5. RESRAD Analysis – All Radionuclides, All-Pathways Dose Rate Estimate for the Overburden.**




### 6.1.2 Nonradionuclides

**6.1.2.1 Direct Comparison to RAGs.** Table 3 compares the cleanup verification statistical values presented in Table 2 to the direct exposure RAGs presented in Table 1.

**Table 3. Attainment of Nonradionuclide Direct Exposure Standards.**

| Nonradionuclides | Direct Exposure RAG (mg/kg) | Statistical Value (mg/kg)[a] | Direct Exposure RAGs Attained?[a] |
|---|---|---|---|
| ***Overburden*** | | | |
| Arsenic | 20 | 11.0 | Yes |
| Hexavalent chromium | 2.1[b] | 0.43 | Yes |
| ***Site Excavation (Shallow Zone)*** | | | |
| Arsenic | 20 | 6.0 | Yes |
| Hexavalent chromium | 2.1[b] | 1.5 | Yes |

[a]Criterion is comparison to the cleanup criteria (RAG).
[b]*Calculation of Hexavalent Chromium Carcinogenic Risk*, 0100X-CA-V0031 (BHI 2000).

**6.1.2.2 Noncarcinogenic Hazard Quotient RAG Attained.** For noncarcinogenic COCs, WAC 173-340 specifies the evaluation of the hazard quotient, which is given as daily intake divided by a reference dose (DOE-RL 1995a). For cleanup actions under the ROD (EPA 1997), a comparable conservative approach is used to demonstrate attainment of the noncarcinogenic risk requirements.

The COCs with noncarcinogenic effects at this site are arsenic and hexavalent chromium. Hexavalent chromium and arsenic are also carcinogens. Carcinogenic risk is discussed in Section 6.1.2.3. The sum of the individual COC hazard quotients for the shallow zone soils is $3.8 \times 10^{-3}$ and the sum of the hazard quotients for the overburden is $1.1 \times 10^{-3}$, which are both below the limit of 1.0. Therefore, the noncarcinogenic risk requirements have been attained. Calculation of the hazard quotient is presented in the 95% UCL calculation brief (Appendix C).

**6.1.2.3 Carcinogenic Risk RAG Attained.** For individual nonradionuclide carcinogenic COCs, the WAC 173-340 Method B cleanup limits are based on an incremental cancer risk of $1 \times 10^{-6}$. For nonradionuclide carcinogenic COCs, the total excess cancer risk must be less than $1 \times 10^{-5}$ (EPA et al. 1998).

The nonradionuclide carcinogenic COCs at this site are hexavalent chromium and arsenic. For the site, the total excess lifetime cancer risk is $7 \times 10^{-7}$. This value is below the individual and total risk limits; therefore, the carcinogenic risk standards have been attained. For the overburden the total excess lifetime cancer risk is $2 \times 10^{-7}$, which is also below the individual and total risk limits. This calculation is documented in the 95% UCL calculation brief (Appendix C).

## 6.2 GROUNDWATER REMEDIAL ACTION GOALS ATTAINED

### 6.2.1 Radionuclides

The estimated groundwater concentrations for all of the radionuclide COCs contributed by the site soils are shown in the RESRAD calculation brief (Appendix C). Table 4 shows the total peak concentration predicted for each radionuclide COC and provides the individual RAGs for comparison. No COC is predicted to exceed the RAGs; therefore, the RAGs are attained.

Figure 6 shows the individual organ dose rates for beta- and gamma-emitting radionuclides predicted over 1,000 years, as shown in the comparison to drinking water standards calculation brief (Appendix C). None of the organ dose rates are predicted to exceed the 4 mrem/yr standard over 1,000 years.

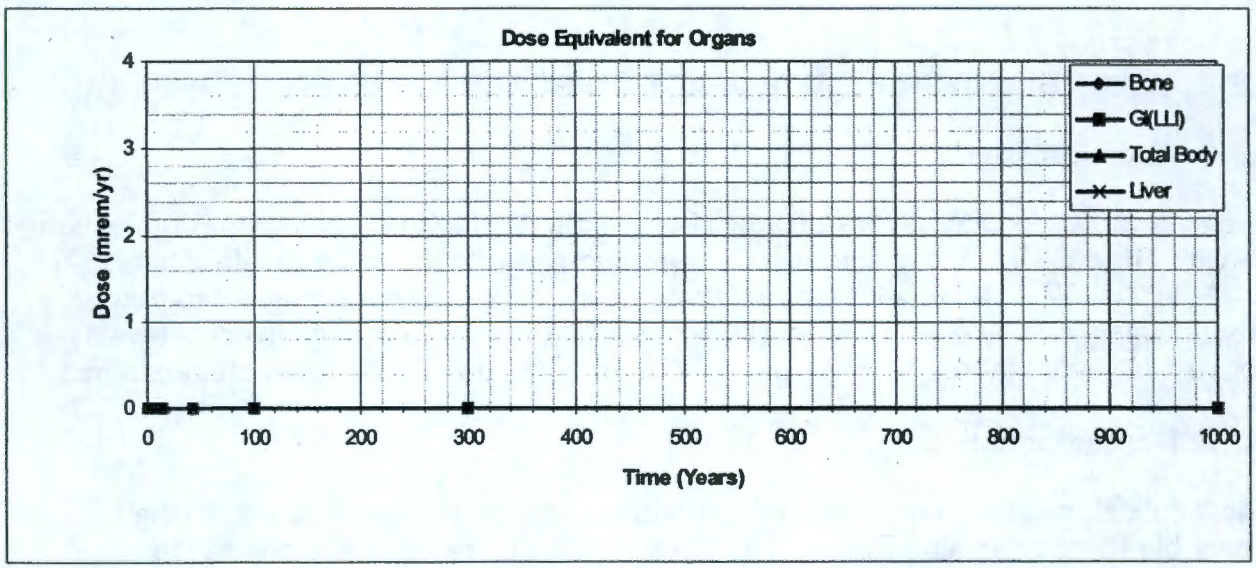
There are no alpha emitters identified at this site; therefore, the drinking water standard for nonuranium alpha emitters and the uranium standard of 30 µg/L have been met. Results of the RESRAD calculations are shown in Appendix C.

**Table 4. Attainment of Radionuclide Remedial Action Goals for Protection of Groundwater and the Columbia River.**

| Radionuclide | Peak Concentration (pCi/L) | RAG (pCi/L) | RAGS Attained? (Yes/No) |
|---|---|---|---|
| ***Shallow Zone*** | | | |
| Carbon-14 | 0.0[a] | 2,000[b] | Yes |
| Cesium-137 | 0.0045 | 60[b] | Yes |
| Cobalt-60 | 0.0093 | 100[b] | Yes |
| Europium-152 | 0.0[a] | 200[b] | Yes |
| Europium-154 | 0.0[a] | 60[b] | Yes |
| ***Overburden*** | | | |
| Carbon-14 | 0.0[a] | 2,000[b] | Yes |
| Cesium-137 | 0.0[a] | 60[b] | Yes |
| Cobalt-60 | 0.0[a] | 100[b] | Yes |
| Europium-152 | 0.0[a] | 200[b] | Yes |
| Europium-154 | 0.0[a] | 60[b] | Yes |

[a]These radionuclides do not reach groundwater in 1,000 years.
[b]Lookup value corresponding to a dose rate of 4 mrem/yr.

**Figure 6. Dose Rates to Organs from Groundwater.**



### 6.2.2 Nonradionuclides

Table 5 illustrates the comparison of cleanup verification statistical values to the groundwater protection RAGs. The table shows that residual concentrations (statistical values) of hexavalent chromium and arsenic for the site are less than the listed groundwater protection soil RAG. The listed RAGs are based on background or the "100 times groundwater cleanup rule." The results of the comparison in Table 5 demonstrate that the RAGs have been attained.

**Table 5. Attainment of Nonradionuclide Remedial Action Goals for Protection of Groundwater and the Columbia River.**

| Nonradionuclides | Soil RAG for Groundwater Protection (mg/kg) | Soil RAG for Columbia River Protection (mg/kg) | Cleanup Verification Data Value (mg/kg) | Does RESRAD Predict Migration to Groundwater in 1,000 Years? | RAGs Attained? (Yes/No) |
|---|---|---|---|---|---|
| ***Overburden*** | | | | | |
| Arsenic | 20 | 20 | 11 | NA | Yes |
| Hexavalent chromium | 8 | 2.0 | 0.43 | NA | Yes |
| ***Shallow Zone*** | | | | | |
| Arsenic | 20 | 20 | 6.0 | NA | Yes |
| Hexavalent chromium | 8 | 2.0 | 1.5 | NA | Yes |

NA = Not applicable. RESRAD modeling was not performed because residual concentrations meet the listed groundwater and river protection RAGs.

## 6.3 COLUMBIA RIVER REMEDIAL ACTION GOALS ATTAINED

### 6.3.1 Radionuclides

The river protection RAGs for radionuclides are identical to the groundwater protection RAGs. The RESRAD modeling results were compared to the groundwater protection RAGs in Table 4. The results indicate that radionuclides are not predicted to reach groundwater (and by extension not predicted to reach the Columbia River) at levels above 4 mrem/yr; therefore, the Columbia River protection RAGs have been attained.

### 6.3.2 Nonradionuclides

Table 5 illustrates the comparison of cleanup verification statistical values to the Columbia River protection RAGs. The table shows that residual concentration (statistical value) of hexavalent chromium and arsenic for the site are less than the listed river protection soil RAG. The listed RAGs are based on background or the "100 times groundwater cleanup rule." The results of the comparison in Table 5 demonstrates that the RAGs have been attained.

## 6.4 WAC 173-340 THREE-PART TEST FOR NONRADIONUCLIDES

Sections 6.1, 6.2, and 6.3 looked separately at compliance with direct exposure RAGs, groundwater protection RAGs, and Columbia River protection RAGs. Section 6.4 documents application of the WAC 173-340 three-part test for nonradionuclides using the most restrictive RAGs applicable for each zone. (The most restrictive RAG is defined as the lowest of the direct exposure, groundwater protection, and river protection RAGs. The direct exposure, groundwater protection, and river protection RAGs are applicable to the shallow zone. Groundwater and river protection RAGs are applicable to the deep zone.) The WAC 173-340 three-part test consists of the following criteria: (1) the cleanup verification statistical value must be less than the cleanup level, (2) no single detection can exceed two times the cleanup criteria, and (3) the percentage of samples exceeding the cleanup criteria must be less than 10%.

Table 6 summarizes the results of the WAC 173-340 three-part test (WAC 173-340-740[7][e]) for the shallow and deep zone sample data sets. For each nonradionuclide COC, the table lists the most restrictive applicable RAG (selected from the RAGs in Table 1), the maximum detected value, the total number of samples collected, and the number of samples exceeding the most restrictive RAG. The final column of the table describes the result of applying the three WAC 173-340 criteria using the values listed in the preceding columns. Table 6 shows that all nonradionuclide COCs pass the WAC 173-340 three-part test for the site excavation and overburden soil.

**Table 6. Application of the WAC 173-340 Three-Part Test.**

| Nonradionuclides | Most Stringent Applicable RAG (mg/kg) | Statistical Value (mg/kg)[a] | Maximum Detected (mg/kg)[b] | Total Number of Samples[c] | Number Exceeding Criteria[d] | RAGs Attained? (Yes/No) |
|---|---|---|---|---|---|---|
| ***Overburden*** | | | | | | |
| Arsenic | 20 | 11 | 16 | 9 | 0 | Yes |
| Hexavalent chromium | 2.0 | 0.43 | 0.4 | 9 | 0 | Yes |
| ***Site Excavation (Shallow Zone)*** | | | | | | |
| Arsenic | 20 | 6.0 | 16 | 30 | 0 | Yes |
| Hexavalent chromium | 2.0 | 1.5 | 1.5 | 30 | 0 | Yes |

[a]Criterion is comparison to the cleanup criteria (RAG).
[b]Criterion is no single detection can exceed two times the cleanup criteria.
[c]The total number of samples includes field duplicate samples, which are included in the evaluation as separate samples.
[d]Criterion is the percentage of samples exceeding the cleanup criteria must be less than 10%.

## 7.0 RADIONUCLIDE RISK INFORMATION

The radionuclide RAG for direct exposure is derived from the ROD (EPA 1997) and is expressed in terms of an allowable radiation dose rate above background (i.e., 15 mrem/yr). The RAG evaluation (Section 5.0) involved using the RESRAD model to estimate total annual radiation dose rates for 1,000 years for comparison to the RAG. Radiation presents a carcinogenic risk, and the RESRAD model also calculates the excess lifetime cancer risk associated with the estimated radiation dose rates using the EPA's Health Effects Assessment Summary Tables (HEAST) (dated April 16, 2001, "Update of Radionuclide Carcinogenicity Slope Factors," available on the Internet at www.epa.gov/radiation/heast). The "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300) presents a target range for residual risk of $10^{-4}$ to $10^{-6}$. Figure 7 illustrates excess lifetime cancer risk associated with the site, and Figure 9 illustrates excess lifetime cancer risk associated with overburden soil as estimated using the RESRAD model. Because of radioactive decay, the risk decreases over time. For the site, the estimated risk is largest, $2.81 \times 10^{-5}$, at present (year 2003), and decreases to $4.58 \times 10^{-16}$ in 1,000 years. The estimated excess cancer risk for the site in 2018 is $9.80 \times 10^{-6}$. Figure 8 plots the radiation dose rate above background for the site, similar to Figure 5, and also shows the corresponding radionuclide risk at present and in 2018. For the overburden, the estimated risk is largest, $7.39 \times 10^{-6}$, at present (year 2003), and decreases to $6.09 \times 10^{-22}$ in 1,000 years. The estimated excess cancer risk for the overburden in 2018 is $2.04 \times 10^{-6}$. Figure 10 plots the radiation dose rate above background for the overburden, similar to Figure 6, and also shows the corresponding radionuclide risk at present and in 2018.

**Figure 7. RESRAD Analysis – Radionuclide Risk for the Site, All Pathways.**

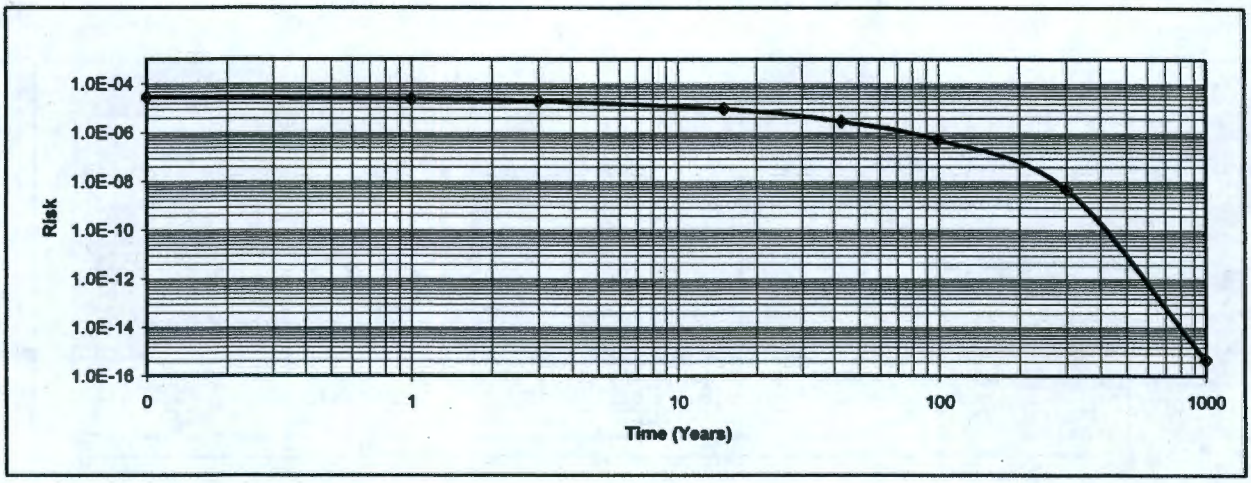



**Figure 8. RESRAD Analysis – Radionuclide Dose Rate for the Site, All Pathways, With Corresponding Risk Values.**

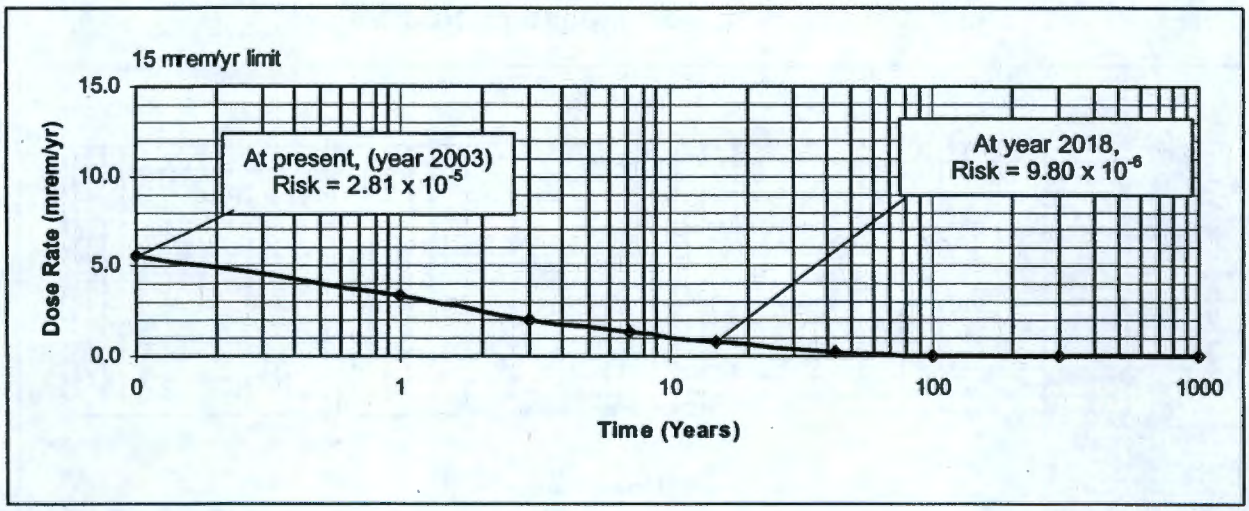


**Figure 9. RESRAD Analysis – Radionuclide Risk for the Overburden, All Pathways.**

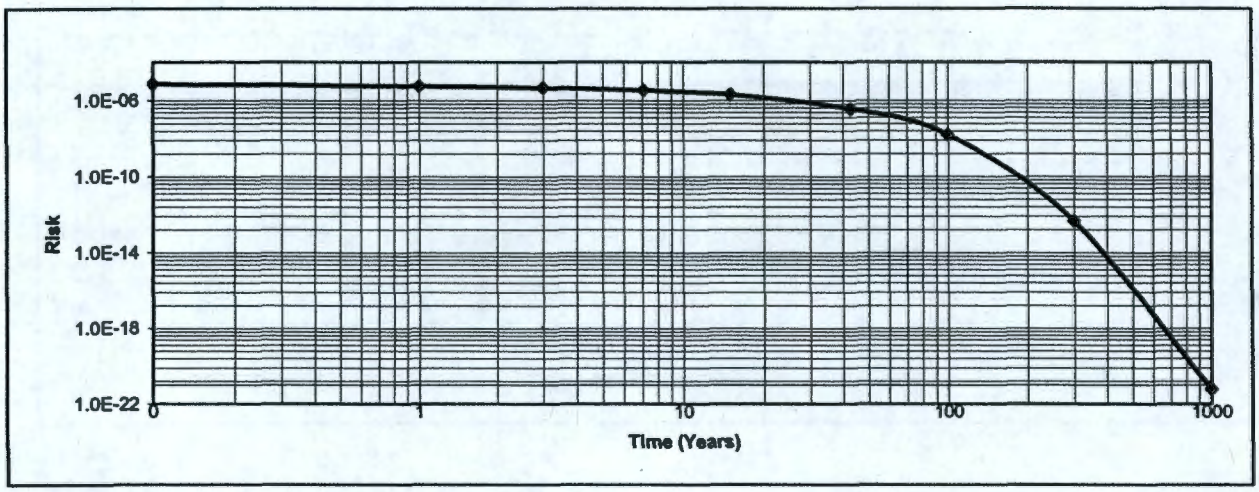
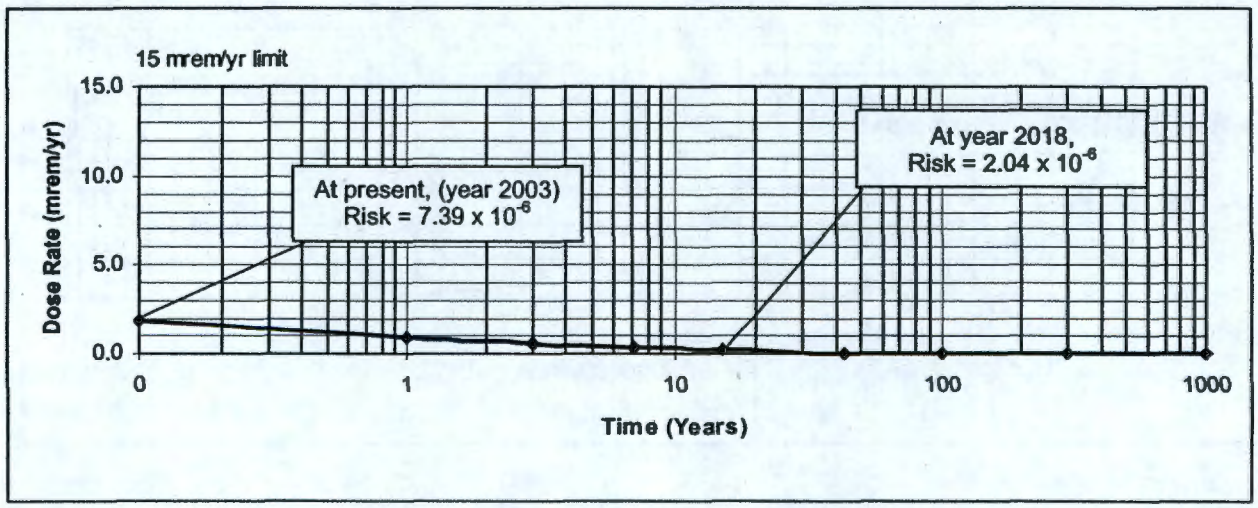



**Figure 10. RESRAD Analysis – Radionuclide Dose Rate for the Overburden, All Pathways, With Corresponding Risk Values.**



## 8.0 STATEMENT OF PROTECTIVENESS

This CVP demonstrates that remedial action at the 116-F-1 site has achieved the RAOs and corresponding RAGs established in the ROD (EPA 1997) and RDR/RAWP (DOE-RL 2002). The remaining soils at the 116-F-1 site have been sampled, analyzed, and modeled. The results of this effort indicate that the materials from the 116-F-1 site containing COCs at concentrations exceeding RAGs have been excavated and disposed of at ERDF. These results also indicate that residual concentrations at the site, including overburden, will support future land uses that can be represented (or bounded) by a rural-residential scenario, and are protective of groundwater and the Columbia River. The 116-F-1 site is verified to be remediated in accordance with the ROD (EPA 1997) and may be backfilled.

## 9.0 REFERENCES

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# APPENDIX A

## SUMMARY OF VERIFICATION SOIL SAMPLING AND ANALYTICAL RESULTS

## Table A-1. Shallow Zone Cleanup Verification Data. (4 Pages)

| Sampling Area | HEIS Number | Sample Date | As | | | Cr+6 | | | C-14 | | | Cs-137 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/kg | Q | PQL | mg/kg | Q | PQL | pCi/g | Q | MDA | pCi/g | Q | MDA |
| SA1 | J00FF9 | 1/07/2003 | 3.0E+00 | | 4.0E-01 | 4.30E-01 | U | 4.30E-01 | 2.75E-01 | U | 3.40E+00 | 1.35E-01 | | 8.90E-02 |
| Duplicate of J00FF9 | J00FH0 | 1/07/2003 | 4.1E+00 | | 4.0E-01 | 4.3E-01 | U | 4.3E-01 | -1.09E+00 | U | 3.70E+00 | 1.57E-01 | | 8.50E-02 |
| Split of J00FF9 | J00FK9 | 1/07/2003 | 3.3E+00 | | 1.0E-01 | 3.98E-01 | | 1.2E-01 | 2.77E-01 | U | 8.07E-01 | 6.35E-02 | | 2.36E-02 |
| SD5 | J00FJ4 | 1/8/2003 | 7.7E+00 | | 2.9E-01 | 4.3E-01 | U | 4.3E-01 | 2.06E+00 | U | 2.70E+00 | 6.30E-02 | | 4.30E-02 |
| Duplicate of J00FJ4 | J00FJ5 | 1/8/2003 | 6.0E+00 | | 3.3E-01 | 4.8E-01 | U | 4.8E-01 | 2.85E+00 | | 2.60E+00 | 1.30E-01 | | 1.10E-01 |
| Split of J00FJ4 | J00FL0 | 1/8/2003 | 6.3E+00 | | 1.1E-01 | -2.6E-02 | U | 8.00E.02 | -2.51E-01 | U | 8.07E-01 | 6.85E-02 | | 2.26E-02 |
| SA2 | J00FH1 | 1/07/2003 | 4.3E+00 | | 3.5E-01 | 4.4E-01 | U | 4.4E-01 | 8.10E-01 | U | 3.60E+00 | 1.07E-01 | U | 1.10E-01 |
| SA3 | J00FH2/J00HL8 | 1/7/2003, 2/26/03 | 3.7E+00 | | 4.3E-01 | 4.2E-01 | U | 4.2E-01 | 3.02E-01 | U | 2.80E+00 | 1.00E-01 | U | 1.00E-01 |
| SA4 | J00FH3/J00HL5 | 1/7/2003, 2/26/03 | 1.7E+00 | | 3.6E-01 | 4.2E-01 | U | 4.2E-01 | 5.09E-01 | U | 3.50E+00 | 5.00E-02 | U | 5.00E-02 |
| SB5 | J00FH4 | 1/07/2003 | 1.9E+00 | | 3.8E-01 | 4.2E-01 | | 4.2E-01 | -2.06E-01 | U | 3.10E+00 | 8.50E-02 | U | 8.50E-02 |
| SB6 | J00FH5/J00HL6 | 1/7/2003, 2/26/03 | 4.1E+00 | | 4.1E-01 | 4.1E-01 | U | 4.1E-01 | -9.80E-02 | U | 3.30E+00 | 1.63E-01 | | 9.40E-02 |
| SB7 | J00FH6 | 1/07/2003 | 2.4E+00 | | 4.0E-01 | 1.3E+00 | | 4.2E-01 | 8.65E-01 | U | 3.10E+00 | 7.40E-02 | U | 7.40E-02 |
| SB8 | J00FH7 | 1/7/2003 | 3.4E+00 | | 3.8E-01 | 6.3E-01 | | 4.3E-01 | 4.35E-01 | U | 3.10E+00 | 7.70E-02 | U | 7.70E-02 |
| SC9 | J00FH8 | 1/7/2003 | 7.3E+00 | | 3.8E-01 | 1.5E+00 | | 4.4E-01 | 4.86E-01 | U | 3.20E+00 | 1.30E-01 | U | 1.30E-01 |
| SC10 | J00FH9 | 1/7/2003 | 6.3E+00 | | 3.5E-01 | 4.5E-01 | U | 4.5E-01 | 1.54E+00 | U | 2.90E+00 | 7.30E-02 | U | 7.30E-02 |
| SC1 | J00FJ0 | 1/7/2003 | 1.3E+01 | | 4.2E-01 | 4.6E-01 | U | 4.6E-01 | 2.32E+00 | U | 2.70E+00 | 1.00E-01 | U | 1.00E-01 |

HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
PQL = practical quantitation limit
U = Analytical result was below laboratory detection limit.

## Table A-1. Shallow Zone Cleanup Verification Data. (4 Pages)

| Sampling Area | HEIS Number | Sample Date | Co-60 | | | Eu-152 | | | Eu-154 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | pCi/g | Q | MDA | pCi/g | Q | MDA | pCi/g | Q | MDA |
| SA1 | J00FF9 | 1/07/2003 | 8.50E-02 | U | 8.50E-02 | 1.90E-01 | U | 1.90E-01 | 2.20E-01 | U | 2.20E-01 |
| Duplicate of J00FF9 | J00FH0 | 1/07/2003 | 9.60E-02 | U | 9.60E-02 | 2.00E-01 | U | 2.00E-01 | 2.90E-01 | U | 2.90E-01 |
| Split of J00FF9 | J00FK9 | 1/07/2003 | -1.70E-03 | U | 2.11E-02 | 7.42E-02 | U | 6.44E-02 | -3.24E-03 | U | 7.06E-02 |
| SD5 | J00FJ4 | 1/8/2003 | 4.20E-02 | U | 4.20E-02 | 1.00E-01 | U | 1.00E-01 | 1.30E-01 | U | 1.30E-01 |
| Duplicate of J00FJ4 | J00FJ5 | 1/8/2003 | 1.00E-01 | U | 1.00E-01 | 2.30E-01 | U | 2.30E-01 | 2.90E-01 | U | 2.90E-01 |
| Split of J00FJ4 | J00FL0 | 1/8/2003 | -2.35E-03 | U | 2.14E-02 | 1.95E-01 | U | 6.55E-02 | 7.06E-03 | U | 6.80E-02 |
| SA2 | J00FH1 | 1/07/2003 | 1.10E-01 | U | 1.10E-01 | 2.50E-01 | U | 2.50E-01 | 2.90E-01 | U | 2.90E-01 |
| SA3 | J00FH2/J00HL8 | 1/7/2003, 2/26/03 | 1.30E-01 | U | 1.30E-01 | 2.50E-01 | U | 2.50E-01 | 3.10E-01 | U | 3.10E-01 |
| SA4 | J00FH3/J00HL5 | 1/7/2003, 2/26/03 | 6.60E-02 | U | 6.60E-02 | 1.40E-01 | U | 1.40E-01 | 2.10E-01 | U | 2.10E-01 |
| SB5 | J00FH4 | 1/07/2003 | 1.00E-01 | U | 1.00E-01 | 1.90E-01 | U | 1.90E-01 | 2.80E-01 | U | 2.80E-01 |
| SB6 | J00FH5/J00HL6 | 1/7/2003, 2/26/03 | 2.70E-01 | U | 2.70E-01 | 6.16E-01 | | 2.40E-01 | 2.50E-01 | U | 2.50E-01 |
| SB7 | J00FH6 | 1/07/2003 | 5.70E-02 | U | 5.70E-02 | 1.20E-01 | U | 1.20E-01 | 1.70E-01 | U | 1.70E-01 |
| SB8 | J00FH7 | 1/7/2003 | 6.30E-02 | U | 6.30E-02 | 1.40E-01 | U | 1.40E-01 | 2.10E-01 | U | 2.10E-01 |
| SC9 | J00FH8 | 1/7/2003 | 1.20E-01 | U | 1.20E-01 | 2.90E-01 | U | 2.90E-01 | 3.90E-01 | U | 3.90E-01 |
| SC10 | J00FH9 | 1/7/2003 | 7.20E-02 | U | 7.20E-02 | 1.80E-01 | U | 1.80E-01 | 2.50E-01 | U | 2.50E-01 |
| SC1 | J00FJ0 | 1/7/2003 | 1.10E-01 | U | 1.10E-01 | 2.70E-01 | U | 2.70E-01 | 2.90E-01 | U | 2.90E-01 |

HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
PQL = practical quantitation limit
U = Analytical result was below laboratory detection limit.

## Table A-1. Shallow Zone Cleanup Verification Data. (4 Pages)

| Sampling Area | HEIS Number | Sample Date | As | | | Cr+6 | | | C-14 | | | Cs-137 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/kg | Q | PQL | mg/kg | Q | PQL | pCi/g | Q | MDA | pCi/g | Q | MDA |
| SC2 | J00FJ1 | 1/7/2003 | 5.7E+00 | | 3.8E-01 | 4.2E-01 | U | 4.2E-01 | 2.10E+00 | U | 2.90E+00 | 9.80E-02 | U | 9.80E-02 |
| SD3 | J00FJ2 | 1/7/2003 | 3.9E+00 | | 3.7E-01 | 1.2E+00 | | 4.6E-01 | 2.05E+00 | U | 2.50E+00 | 6.60E-02 | U | 6.60E-02 |
| SD4 | J00FJ3 | 1/7/2003 | 6.0E+00 | | 4.2E-01 | 4.5E-01 | U | 4.5E-01 | 8.30E-01 | U | 2.20E+00 | 8.00E-02 | U | 8.00E-02 |
| SD6 | J00FJ6 | 1/8/2003 | 5.5E+00 | | 4.3E-01 | 1.2E+00 | | 4.6E-01 | 2.37E+00 | U | 2.40E+00 | 2.43E-01 | | 2.90E-02 |
| SE7 | J00FJ7 | 1/8/2003 | 4.0E+00 | | 4.2E-01 | 4.4E-01 | U | 4.4E-01 | 1.30E+00 | U | 2.50E+00 | 3.00E-02 | U | 3.00E-02 |
| SE8 | J00FJ8 | 1/8/2003 | 5.7E+00 | | 4.1E-01 | 4.6E-01 | U | 4.6E-01 | 1.46E+00 | U | 2.20E+00 | 5.60E-02 | U | 5.60E-02 |
| SE9 | J00FJ9/J00HL7 | 1/7/2003, 2/26/03 | 2.6E+00 | | 3.9E-01 | 4.5E-01 | U | 4.5E-01 | 1.05E+00 | U | 2.50E+00 | 1.74E-01 | | 1.20E-01 |
| SE10 | J00FK0 | 1/8/2003 | 1.6E+01 | | 3.8E-01 | 4.4E-01 | U | 4.4E-01 | 1.47E+00 | U | 2.90E+00 | 7.10E-02 | U | 7.10E-02 |
| SF1 | J00FK1 | 1/8/2003 | 3.8E+00 | | 3.9E-01 | 4.7E-01 | U | 4.7E-01 | 1.97E+00 | U | 3.60E+00 | 9.00E-02 | U | 9.00E-02 |
| SF2 | J00FK2 | 1/8/2003 | 2.3E+00 | | 3.8E-01 | 4.2E-01 | U | 4.2E-01 | 1.02E+00 | U | 2.50E+00 | 9.20E-02 | U | 9.20E-02 |
| SF3 | J00FK3 | 1/8/2003 | 3.7E+00 | | 4.2E-01 | 4.8E-01 | | 4.5E-01 | 1.55E+00 | U | 2.40E+00 | 9.00E-02 | U | 9.00E-02 |
| SF4 | J00FK4 | 1/8/2003 | 5.2E+00 | | 4.0E-01 | 6.4E-01 | | 4.2E-01 | 1.04E+00 | U | 2.30E+00 | 1.00E-01 | U | 1.00E-01 |
| SG5 | J00FK5 | 1/8/2003 | 6.1E+00 | | 4.2E-01 | 4.4E-01 | U | 4.4E-01 | 1.81E+00 | U | 2.00E+00 | 9.50E-02 | U | 9.50E-02 |
| SG6 | J00FK6 | 1/8/2003 | 3.5E+00 | | 3.7E-01 | 4.4E-01 | U | 4.4E-01 | 1.91E+00 | U | 2.50E+00 | 7.50E-02 | U | 7.50E-02 |
| SG7 | J00FK7 | 1/8/2003 | 2.3E+00 | | 4.1E-01 | 4.3E-01 | U | 4.3E-01 | 1.06E+00 | U | 2.10E+00 | 1.00E-01 | U | 1.00E-01 |
| SG8 | J00FK8 | 1/8/2003 | 2.1E+00 | | 3.6E-01 | 4.3E-01 | U | 4.3E-01 | 2.14E+00 | | 2.10E+00 | 5.50E-02 | U | 5.50E-02 |

HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
PQL = practical quantitation limit
U = Analytical result was below laboratory detection limit.

## Table A-1. Shallow Zone Cleanup Verification Data. (4 Pages)

| Sampling Area | HEIS Number | Sample Date | Co-60 | | | Eu-152 | | | Eu-154 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | pCi/g | Q | MDA | pCi/g | Q | MDA | pCi/g | Q | MDA |
| SC2 | J00FJ1 | 1/7/2003 | 1.00E-01 | U | 1.00E-01 | 2.30E-01 | U | 2.30E-01 | 2.90E-01 | U | 2.90E-01 |
| SD3 | J00FJ2 | 1/7/2003 | 7.70E-02 | U | 7.70E-02 | 1.60E-01 | U | 1.60E-01 | 2.30E-01 | U | 2.30E-01 |
| SD4 | J00FJ3 | 1/7/2003 | 8.70E-02 | U | 8.70E-02 | 2.30E-01 | U | 2.30E-01 | 2.80E-01 | U | 2.80E-01 |
| SD6 | J00FJ6 | 1/8/2003 | 7.80E-02 | U | 7.80E-02 | 5.61E-01 | | 6.50E-02 | 1.00E-01 | U | 1.00E-01 |
| SE7 | J00FJ7 | 1/8/2003 | 3.20E-02 | U | 3.20E-02 | 7.50E-02 | U | 7.50E-02 | 1.10E-01 | U | 1.10E-01 |
| SE8 | J00FJ8 | 1/8/2003 | 3.50E-02 | U | 3.50E-02 | 8.20E-02 | U | 8.20E-02 | 1.10E-01 | U | 1.10E-01 |
| SE9 | J00FJ9/J00HL7 | 1/7/2003, 2/26/03 | 1.20E-01 | U | 1.20E-01 | 2.31E-01 | U | 2.50E-01 | 3.50E-01 | U | 3.50E-01 |
| SE10 | J00FK0 | 1/8/2003 | 7.40E-02 | U | 7.40E-02 | 1.70E-01 | U | 1.70E-01 | 2.30E-01 | U | 2.30E-01 |
| SF1 | J00FK1 | 1/8/2003 | 1.90E-01 | U | 1.90E-01 | 2.40E-01 | U | 2.40E-01 | 3.20E-01 | U | 3.20E-01 |
| SF2 | J00FK2 | 1/8/2003 | 1.10E-01 | U | 1.10E-01 | 2.20E-01 | U | 2.20E-01 | 2.70E-01 | U | 2.70E-01 |
| SF3 | J00FK3 | 1/8/2003 | 9.60E-02 | U | 9.60E-02 | 2.20E-01 | U | 2.20E-01 | 2.90E-01 | U | 2.90E-01 |
| SF4 | J00FK4 | 1/8/2003 | 1.10E-01 | U | 1.10E-01 | 2.60E-01 | U | 2.60E-01 | 3.30E-01 | U | 3.30E-01 |
| SG5 | J00FK5 | 1/8/2003 | 9.40E-02 | U | 9.40E-02 | 2.00E-01 | U | 2.00E-01 | 2.70E-01 | U | 2.70E-01 |
| SG6 | J00FK6 | 1/8/2003 | 7.00E-02 | U | 7.00E-02 | 1.60E-01 | U | 1.60E-01 | 2.30E-01 | U | 2.30E-01 |
| SG7 | J00FK7 | 1/8/2003 | 7.60E-02 | U | 7.60E-02 | 2.20E-01 | U | 2.20E-01 | 3.50E-01 | U | 3.50E-01 |
| SG8 | J00FK8 | 1/8/2003 | 6.20E-02 | U | 6.20E-02 | 1.30E-01 | U | 1.30E-01 | 1.90E-01 | U | 1.90E-01 |

HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
PQL = practical quantitation limit
U = Analytical result was below laboratory detection limit.

## Table A-2. Overburden Cleanup Verification Data. (2 Pages)

| Sample Area | HEIS Number | Sample Date | As | | | Cr+6 | | | C-14 | | | Cs-137 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/kg | Q | PQL | mg/kg | Q | PQL | pCi/g | Q | MDA | pCi/g | Q | MDA |
| OA1 | J00C01 | 12/11/2002 | 3.3E+00 | | 4.0E-01 | 4.3E-01 | U | 4.3E-01 | -7.57E-01 | U | 2.00E+00 | 4.40E-02 | U | 4.40E-02 |
| Duplicate of J00C01 | J00C09 | 12/11/2002 | 3.5E+00 | | 3.9E-01 | 4.2E-01 | U | 4.2E-01 | -6.25E-01 | U | 2.90E+00 | 4.10E-02 | U | 4.10E-02 |
| Split of J00C01 | J00C11 | 12/11/2002 | 2.7E+00 | | 1.0E-01 | 2.4E-02 | U | 8.0E-02 | 1.70E-02 | U | 3.16E-01 | 4.15E-02 | | 2.10E-02 |
| OA2 | J00C02 | 12/11/2002 | 3.5E+00 | | 4.1E-01 | 4.3E-01 | U | 4.3E-01 | 1.66E-01 | U | 1.80E+00 | 4.50E-02 | U | 4.50E-02 |
| OA3 | J00C03/J00HL9 | 12/11/2002, 2/26/03 | 3.6E+00 | | 4.0E-01 | 4.2E-01 | U | 4.2E-01 | 4.12E-01 | U | 1.90E+00 | 3.90E-02 | U | 3.90E-02 |
| OA4 | J00C04 | 12/11/2002 | 1.0E+01 | | 3.9E-01 | 4.2E-01 | U | 4.2E-01 | 8.10E-02 | U | 1.80E+00 | 5.30E-02 | U | 5.30E-02 |
| OB5 | J00C05 | 12/11/2002 | 1.6E+01 | | 4.0E-01 | 4.2E-01 | U | 4.2E-01 | -1.02E+00 | U | 2.90E+00 | 4.00E-02 | U | 4.00E-02 |
| OB6 | J00C06 | 12/11/2002 | 1.2E+01 | | 3.7E-01 | 4.2E-01 | U | 4.2E-01 | -1.13E-01 | U | 3.40E+00 | 6.10E-02 | U | 6.10E-02 |
| OB7 | J00C07 | 12/11/2002 | 1.0E+01 | | 3.8E-01 | 4.2E-01 | U | 4.2E-01 | 2.30E+00 | U | 3.50E+00 | 5.40E-02 | U | 5.40E-02 |
| OB8 | J00C08 | 12/11/2002 | 5.0E+00 | | 4.0E-01 | 4.3E-01 | U | 4.3E-01 | -1.15E+00 | U | 3.30E+00 | 4.00E-02 | U | 4.00E-02 |

HEIS = Hanford Environmental Information System
MDA = minimum detectable activity
PQL = practical quantitation limit
U = Analytical result was below laboratory detection limit.

## Table A-2. Overburden Cleanup Verification Data. (2 Pages)

| Sample Area | HEIS Number | Sample Date | C0-60 | | | Eu-152 | | | Eu-154 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | pCi/g | Q | MDA | pCi/g | Q | MDA | pCi/g | Q | MDA |
| OA1 | J00C01 | 12/11/2002 | 4.70E-02 | U | 4.70E-02 | 1.10E-01 | U | 1.10E-01 | 1.70E-01 | U | 1.70E-01 |
| Duplicate of J00C01 | J00C09 | 12/11/2002 | 4.30E-02 | U | 4.30E-02 | 9.90E-02 | U | 9.90E-02 | 1.40E-01 | U | 1.40E-01 |
| Split of J00C01 | J00C11 | 12/11/2002 | 1.43E-02 | U | 2.40E-02 | -1.53E-02 | U | 5.43E-02 | 3.85E-03 | U | 6.56E-02 |
| OA2 | J00C02 | 12/11/2002 | 4.90E-02 | U | 4.90E-02 | 1.10E-01 | U | 1.10E-01 | 1.60E-01 | U | 1.60E-01 |
| OA3 | J00C03/J00HL9 | 12/11/2002, 2/26/03 | 4.00E-02 | U | 4.00E-02 | 9.00E-02 | U | 9.00E-02 | 1.40E-01 | U | 1.40E-01 |
| OA4 | J00C04 | 12/11/2002 | 4.80E-02 | U | 4.80E-02 | 1.10E-01 | U | 1.10E-01 | 1.50E-01 | U | 1.50E-01 |
| OB5 | J00C05 | 12/11/2002 | 4.10E-02 | U | 4.10E-02 | 8.70E-02 | U | 8.70E-02 | 1.40E-01 | U | 1.40E-01 |
| OB6 | J00C06 | 12/11/2002 | 3.90E-02 | U | 3.90E-02 | 9.00E-02 | U | 9.00E-02 | 1.40E-01 | U | 1.40E-01 |
| OB7 | J00C07 | 12/11/2002 | 5.70E-02 | U | 5.70E-02 | 1.10E-01 | U | 1.10E-01 | 2.00E-01 | U | 2.00E-01 |
| OB8 | J00C08 | 12/11/2002 | 4.00E-02 | U | 4.00E-02 | 8.50E-02 | U | 8.50E-02 | 1.20E-01 | U | 1.20E-01 |

HEIS = Hanford Environmental Information System
MDA = Minimum detectable activity
PQL = practical quantitation limit
U = Analytical result was below laboratory detection limit.

# APPENDIX B

# DATA QUALITY ASSESSMENT

# B1.0 DATA QUALITY ASSESSMENT FOR THE 116-F-1 SITE

## B1.1 OVERVIEW

This data quality assessment (DQA) was 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 involves the scientific and statistical evaluation of the data to determine if they are of the right type, quality, and quantity to support their intended use (i.e., closeout decisions [EPA 2000]). The DQA completes the data life cycle (i.e., planning, implementation, and assessment) that was initiated by the data quality objectives process.

This DQA was performed in accordance with BHI-EE-01, *Environmental Investigations Procedures*. Specific data quality objectives for the site are found in the *100 Area Remedial Action Sampling and Analysis Plan* (SAP) (DOE-RL 2001). 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 (DOE-RL 2001) and the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP) (DOE-RL 2002).

Prior to performing statistical tests, all of the analytical data are evaluated and a portion are validated for compliance with quality assurance (QA) project plan requirements (DOE-RL 2001). 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 test is performed on the adjusted raw analytical data (see calculation briefs in Appendix C) to determine statistical values for each contaminant. The number of samples collected for cleanup verification is then evaluated to confirm assumptions concerning contaminant variability.

The DQA for the 116-F-1 site determined that the data are of the right type, quality, and quantity to support site cleanup verification decisions within specified error tolerances. All analytical data were found to be acceptable for decision-making purposes. The evaluation verified that the sample design was sufficient for the purpose of clean site verification. Additional quality requirements of the QA project plan included data acquisition requirements. The cleanup verification sample analytical data are stored in the Hanford Environmental Information System and are summarized in Appendix A.

The following subsections describe the DQA results for the 116-F-1 site, including formal data validation, supplementary data evaluation, and field QA/quality control (QC) program results. The statistical evaluation of the data is provided in the calculation brief excerpts included in Appendix C.

## B1.2 DATA VALIDATION

### B1.2.1 Laboratory QA/QC Analysis

All verification samples are subject to laboratory-specific QA requirements, including instrument procurement, maintenance, calibration, and operation. Additional laboratory requirements for internal QC checks are performed, as appropriate, for the analytical method at a rate of 1 per sample delivery group (SDG), or 1 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 [MS]) 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 [LCS] 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.

Verification sample laboratories are also subject to periodic and random assessments of the laboratory performance, systems, and overall program. These assessments are performed by the Bechtel Hanford, Inc. QA group to ensure that the laboratories are performing to meet laboratory contract requirements.

### B1.2.2 Data Validation Results

After sampling was completed, all of the fixed-base laboratory data from one SDG, H2024, were validated to Level C per BHI-EE-01, Procedure 2.5, "Data Package Validation Process." Level C validation procedures are specified in *Data Validation Procedure for Radiochemical Analysis* (BHI 2000a) and *Data Validation Procedure for Chemical Analysis* (BHI 2000b). Validation was performed by Tech Law, Inc. (Tech Law 2003a, 2003b).

Under the Level C validation procedure, the following items were reviewed, as appropriate, for each analytical method:

- Sample holding times
- Method blanks
- MS recovery
- Surrogate recovery
- MS/matrix spike duplicate results
- Sample replicates
- Associated batch laboratory control sample results
- Data package completeness
- Achievement of target (or contractual) detection limits (TDLs).

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 as 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 TDLs pursuant to the SAP (DOE-RL 2001). 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 TDL with the respective MDA or PQL is discussed in Section B1.3.

A summary of deficiencies noted during validation of SDG H2024 follows.

Radionuclides. The DQA noted no major deficiencies. Minor deficiencies noted during validation include the following:

- Of the 14 nondetect results reported above their TDLs, none exceeded the TDL by more than a factor of 2. All missed TDL nondetects in the validated results were less than one-tenth of their associated remedial action goals (RAGs). Additional discussion on analyses with missed TDLs is provided in Section B1.3.

Nonradionuclides. No major or minor deficiencies were noted for nonradionuclides during validation.

## B1.3 DATA EVALUATION

The formal data validation described in the previous section included evaluation of only one SDG; however, DQA is required for all SDGs. Therefore, supplementary data evaluation was performed on the remaining SDGs. The following paragraphs include the results of the data evaluation of all SDGs.

To ensure adequate data quality, DQA investigators reviewed the study objectives in the SAP (DOE-RL 2001) to determine the context for assessing the data. The context for assessing the data includes evaluating the sample data using the statistical methodology of the SAP (included in the calculation brief excerpts in Appendix C) and a comparison of analytical results to the PARCC (precision, accuracy, representativeness, completeness, and comparability) parameters as specified in the SAP (DOE-RL 2001). This section summarizes the results of the PARCC parameter comparison and presents an evaluation of the affected data.

TDL Comparison: Reported analytical detection levels for nondetected analytes were compared to the TDLs specified in the SAP (DOE-RL 2001). When detected results are obtained, evaluation of detection limits is not performed. The data validation and supplemental data evaluation noted any analyses in which the detection limit (MDA or PQL) was above the SAP TDLs for nondetected analytes.

The reported MDA was above the TDL for the following contaminants of concern (COCs):

- Cesium-137: 6 of 32 nondetect results
- Cobalt-60: 33 of 44 nondetect results
- Europium-152: 34 of 42 nondetect results
- Europium-154: 43 of 44 nondetect results.

Of the 101 nondetect results reported above their TDLs, only 8 exceeded the TDL by more than a factor of 3. All missed TDL nondetects in shallow zone and overburden samples were less than one-tenth of their associated RAGs with eight exceptions: 0.27 pCi/g and 0.19 pCi/g versus 1.4 pCi/g for cobalt-60; 0.31 pCi/g, 0.32 pCi/g, 0.33 pCi/g, 0.35 pCi/g, 0.35 pCi/g, and 0.39 pCi/g versus 3.0 pCi/g for europium-154. Because the reported values are sufficiently less than the RAGs, the associated data are of sufficient quality for decision-making purposes (DOE-RL 2002).

All other nondetected analyses had detection limits below the TDL.

Precision and Accuracy Evaluation: Analytical accuracy and precision were evaluated by examination of the percent recovery and RPD between the main and duplicate samples. Only the COCs detected at five times the detection limit (or greater) are used for data analysis with respect to accuracy and precision.

The RPDs for laboratory duplicates were within acceptable limits for all COCs except as follows:

- The cesium-137 sample batch laboratory duplicate result (duplicate performed on another sample in the batch) for sample J00FJ6 was 33%, which is slightly higher than the contractual control limit of 30%. Other results in the duplicate analysis were within control limits. Because the result for cesium-137 was well below the cleanup criteria, and the RPD is very near the contractual limit, the data are of sufficient quality for decision-making purposes.

Spike recoveries for laboratory batches were within acceptable limits for all COCs except as follows:

- In shallow zone field split sample J00FF8, the laboratory hexavalent chromium MS recovery was 59%, which is outside control limits (±30%). The laboratory notes that the low recovery indicates matrix effects. The LCS recovery results for this data package (SDG W03941), including the LCS result for hexavalent chromium, generally indicate that the laboratory methodology is working well, which is one purpose of the MS analysis. Thus, the low MS recovery is assumed to be attributable to limited matrix heterogeneity, and the data are believed to be of sufficient quality for decision-making purposes.

All other parameters meet acceptance criteria.

## B1.4 FIELD QA/QC

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 included one equipment blank (J00C10), and the following field duplicate and split samples:

Duplicate pairs:

Sample J00FH0, duplicate of shallow zone sample J00FF9
Sample J00FJ5, duplicate of shallow zone sample J00FJ4
Sample J00C09, duplicate of overburden sample J00C01.

Split pairs:

Sample J00FK9, split of shallow zone sample J00FH0
Sample J00FL0, split of shallow zone sample J00FJ4
Sample J00C11, split of overburden sample J00C01.

### B1.4.1 Equipment Blank Samples

One equipment blank sample (J00C10) was collected as part of the QA/QC measures. The blank sample results for this site were less than detection for all COCs.

### B1.4.2 Field Duplicate Samples

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.

Based on these criteria, calculation of the RPD was required for arsenic in both shallow zone duplicate pairs, and in the overburden pair as well. All RPD results were within the +/-30% range with one exception. The RPD between samples J00FH0 and J00FF9 was 31%, which is very close to the +/-30% limit. These field QA/QC sample results tend to suggest a limited degree of heterogeneity with regard to arsenic. Variance analysis (Appendix C) indicates that the number of verification samples that were taken at this site is sufficient for cleanup verification. The use of statistical values described in Section 5.0 is used to compensate for COC variance at the site and ensure that decisions are made within acceptable error tolerance. On this basis, the usefulness of these data is not affected.

### B1.4.3 Field Split Samples

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 TDLs or contract required detection limit for both the main and split sample were compared.

Based on these criteria, calculation of the RPD was required for arsenic in both shallow zone split pairs, and in the overburden pair as well. All RPD results were within the +/-30% range.

## B1.5 SUITABILITY OF DATA

The conclusion of the DQA is that the data are of the right type, quality, and quantity to support the intended use. Detection limits, precision, accuracy, and SDG completeness were analyzed to determine if any analytical results should be rejected as a result of QA/QC deficiencies. All COC analytical data were found to be acceptable for decision-making purposes, and the raw data are acceptable for calculating the required statistical values.

## B2.0 REFERENCES

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

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

BHI-EE-01, *Environmental Investigations Procedures*, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 2001, *100 Area Remedial Action Sampling and Analysis Plan*, DOE/RL-96-22, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2002, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 4, 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.

Tech Law, 2003a, *Inorganics - Data Package No. H2024-LLI (SDG No. H2024)*, Tech Law, Inc., Richland, Washington.

Tech Law, 2003b, *Radionuclides - Data Package No. H2024-EB (SDG No. H2024)*, Tech Law, Inc., Richland, Washington.

# APPENDIX C

# RESRAD INPUT PARAMETERS AND CALCULATION BRIEF EXCERPTS

# RESRAD INPUT PARAMETERS FOR THE SHALLOW ZONE

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

| 0 Menu | Parameter | Current Value | Default | Parameter Name |
|---|---|---|---|---|
| B-1 | Dose conversion factors for inhalation, mrem/pCi: | | | |
| B-1 | C-14 | 2.090E-06 | 2.090E-06 | DCF2( 1) |
| B-1 | Co-60 | 2.190E-04 | 2.190E-04 | DCF2( 2) |
| B-1 | Cs-137+D | 3.190E-05 | 3.190E-05 | DCF2( 3) |
| B-1 | Eu-152 | 2.210E-04 | 2.210E-04 | DCF2( 4) |
| B-1 | Eu-154 | 2.860E-04 | 2.860E-04 | DCF2( 6) |
| B-1 | Gd-152 | 2.430E-01 | 2.430E-01 | DCF2( 7) |
| D-1 | Dose conversion factors for ingestion, mrem/pCi: | | | |
| D-1 | C-14 | 2.090E-06 | 2.090E-06 | DCF3( 1) |
| D-1 | Co-60 | 2.690E-05 | 2.690E-05 | DCF3( 2) |
| D-1 | Cs-137+D | 5.000E-05 | 5.000E-05 | DCF3( 3) |
| D-1 | Eu-152 | 6.480E-06 | 6.480E-06 | DCF3( 4) |
| D-1 | Eu-154 | 9.550E-06 | 9.550E-06 | DCF3( 6) |
| D-1 | Gd-152 | 1.610E-04 | 1.610E-04 | DCF3( 7) |
| D-34 | Food transfer factors: | | | |
| D-34 | C-14 , plant/soil concentration ratio, dimensionless | 5.500E+00 | 5.500E+00 | RTF( 1,1) |
| D-34 | C-14 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 3.100E-02 | 3.100E-02 | RTF( 1,2) |
| D-34 | C-14 , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 1.200E-02 | 1.200E-02 | RTF( 1,3) |
| D-34 | Co-60 , plant/soil concentration ratio, dimensionless | 8.000E-02 | 8.000E-02 | RTF( 2,1) |
| D-34 | Co-60 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 2.000E-02 | 2.000E-02 | RTF( 2,2) |
| D-34 | Co-60 , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 2.000E-03 | 2.000E-03 | RTF( 2,3) |
| D-34 | Cs-137+D , plant/soil concentration ratio, dimensionless | 4.000E-02 | 4.000E-02 | RTF( 3,1) |
| D-34 | Cs-137+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 3.000E-02 | 3.000E-02 | RTF( 3,2) |
| D-34 | Cs-137+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 8.000E-03 | 8.000E-03 | RTF( 3,3) |
| D-34 | Eu-152 , plant/soil concentration ratio, dimensionless | 2.500E-03 | 2.500E-03 | RTF( 4,1) |
| D-34 | Eu-152 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 2.000E-03 | 2.000E-03 | RTF( 4,2) |
| D-34 | Eu-152 , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 2.000E-05 | 2.000E-05 | RTF( 4,3) |
| D-34 | Eu-154 , plant/soil concentration ratio, dimensionless | 2.500E-03 | 2.500E-03 | RTF( 6,1) |
| D-34 | Eu-154 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 2.000E-03 | 2.000E-03 | RTF( 6,2) |
| D-34 | Eu-154 , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 2.000E-05 | 2.000E-05 | RTF( 6,3) |
| D-34 | Gd-152 , plant/soil concentration ratio, dimensionless | 2.500E-03 | 2.500E-03 | RTF( 7,1) |
| D-34 | Gd-152 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 2.000E-03 | 2.000E-03 | RTF( 7,2) |
| D-34 | Gd-152 , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 2.000E-05 | 2.000E-05 | RTF( 7,3) |
| D-5 | Bioaccumulation factors, fresh water, L/kg: | | | |
| D-5 | C-14 , fish | 5.000E+04 | 5.000E+04 | BIOFAC( 1,1) |
| D-5 | C-14 , crustacea and mollusks | 9.100E+03 | 9.100E+03 | BIOFAC( 1,2) |
| D-5 | Co-60 , fish | 3.000E+02 | 3.000E+02 | BIOFAC( 2,1) |
| D-5 | Co-60 , crustacea and mollusks | 2.000E+02 | 2.000E+02 | BIOFAC( 2,2) |
| D-5 | Cs-137+D , fish | 2.000E+03 | 2.000E+03 | BIOFAC( 3,1) |
| D-5 | Cs-137+D , crustacea and mollusks | 1.000E+02 | 1.000E+02 | BIOFAC( 3,2) |

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

| 0 Menu | Parameter | Current Value | Default | Parameter Name |
|---|---|---|---|---|
| D-5 | Eu-152 , fish | 5.000E+01 | 5.000E+01 | BIOFAC( 4,1) |
| D-5 | Eu-152 , crustacea and mollusks | 1.000E+03 | 1.000E+03 | BIOFAC( 4,2) |
| D-5 | | | | |
| D-5 | Eu-154 , fish | 5.000E+01 | 5.000E+01 | BIOFAC( 6,1) |
| D-5 | Eu-154 , crustacea and mollusks | 1.000E+03 | 1.000E+03 | BIOFAC( 6,2) |
| D-5 | | | | |
| D-5 | Gd-152 , fish | 2.500E+01 | 2.500E+01 | BIOFAC( 7,1) |
| D-5 | Gd-152 , crustacea and mollusks | 1.000E+03 | 1.000E+03 | BIOFAC( 7,2) |

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Site-Specific Parameter Summary

| 0 Menu | Parameter | User Input | Default | Used by RESRAD (If different from user input) | Parameter Name |
|---|---|---|---|---|---|
| R011 | Area of contaminated zone (m**2) | 2.482E+04 | 1.000E+04 | --- | AREA |
| R011 | Thickness of contaminated zone (m) | 6.400E+00 | 2.000E+00 | --- | THICK0 |
| R011 | Length parallel to aquifer flow (m) | 3.100E+01 | 1.000E+02 | --- | LCZPAQ |
| R011 | Basic radiation dose limit (mrem/yr) | 1.500E+01 | 2.500E+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) | 7.100E+00 | 1.000E+01 | --- | T( 4) |
| R011 | Times for calculations (yr) | 1.500E+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): C-14 | 1.470E+00 | 0.000E+00 | --- | S1( 1) |
| R012 | Initial principal radionuclide (pCi/g): Co-60 | 5.490E-02 | 0.000E+00 | --- | S1( 2) |
| R012 | Initial principal radionuclide (pCi/g): Cs-137 | 1.100E-01 | 0.000E+00 | --- | S1( 3) |
| R012 | Initial principal radionuclide (pCi/g): Eu-152 | 1.770E-01 | 0.000E+00 | --- | S1( 4) |
| R012 | Initial principal radionuclide (pCi/g): Eu-154 | 1.370E-01 | 0.000E+00 | --- | S1( 6) |
| R012 | Concentration in groundwater (pCi/L): C-14 | not used | 0.000E+00 | --- | W1( 1) |
| R012 | Concentration in groundwater (pCi/L): Co-60 | not used | 0.000E+00 | --- | W1( 2) |
| R012 | Concentration in groundwater (pCi/L): Cs-137 | not used | 0.000E+00 | --- | W1( 3) |
| R012 | Concentration in groundwater (pCi/L): Eu-152 | not used | 0.000E+00 | --- | W1( 4) |
| R012 | Concentration in groundwater (pCi/L): Eu-154 | not used | 0.000E+00 | --- | W1( 6) |
| | | | | | |
| R013 | Cover depth (m) | 0.000E+00 | 0.000E+00 | --- | COVER0 |
| R013 | Density of cover material (g/cm**3) | not used | 1.500E+00 | --- | DENSCV |
| R013 | Cover depth erosion rate (m/yr) | not used | 1.000E-03 | --- | VCV |
| R013 | Density of contaminated zone (g/cm**3) | 1.600E+00 | 1.500E+00 | --- | DENSCZ |
| R013 | Contaminated zone erosion rate (m/yr) | 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 |

Site-Specific Parameter Summary (continued)

| 0 Menu | Parameter | User Input | Default | Used by RESRAD (If different from user input) | Parameter Name |
|---|---|---|---|---|---|
| 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 |
| R015 | Number of unsaturated zone strata | 0 | 1 | --- | NS |
| R016 | Distribution coefficients for C-14 | | | | |
| R016 | Contaminated zone (cm**3/g) | 2.000E+02 | 0.000E+00 | --- | DCNUCC( 1) |
| R016 | Saturated zone (cm**3/g) | 2.000E+02 | 0.000E+00 | --- | DCNUCS( 1) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 3.900E-05 | ALEACH( 1) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 1) |
| R016 | Distribution coefficients for Co-60 | | | | |
| R016 | Contaminated zone (cm**3/g) | 5.000E+01 | 1.000E+03 | --- | DCNUCC( 2) |
| R016 | Saturated zone (cm**3/g) | 5.000E+01 | 1.000E+03 | --- | DCNUCS( 2) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 1.557E-04 | ALEACH( 2) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 2) |
| R016 | Distribution coefficients for Cs-137 | | | | |
| R016 | Contaminated zone (cm**3/g) | 5.000E+01 | 1.000E+03 | --- | DCNUCC( 3) |
| R016 | Saturated zone (cm**3/g) | 5.000E+01 | 1.000E+03 | --- | DCNUCS( 3) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 1.557E-04 | ALEACH( 3) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 3) |
| R016 | Distribution coefficients for Eu-152 | | | | |
| R016 | Contaminated zone (cm**3/g) | 2.000E+02 | -1.000E+00 | --- | DCNUCC( 4) |
| R016 | Saturated zone (cm**3/g) | 2.000E+02 | -1.000E+00 | --- | DCNUCS( 4) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 3.900E-05 | ALEACH( 4) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 4) |
| R016 | Distribution coefficients for Eu-154 | | | | |
| R016 | Contaminated zone (cm**3/g) | 2.000E+02 | -1.000E+00 | --- | DCNUCC( 6) |
| R016 | Saturated zone (cm**3/g) | 2.000E+02 | -1.000E+00 | --- | DCNUCS( 6) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 3.900E-05 | ALEACH( 6) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 6) |
| R016 | Distribution coefficients for daughter Gd-152 | | | | |
| R016 | Contaminated zone (cm**3/g) | -1.000E+00 | -1.000E+00 | 8.249E+02 | DCNUCC( 7) |
| R016 | Saturated zone (cm**3/g) | -1.000E+00 | -1.000E+00 | 8.249E+02 | DCNUCS( 7) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 9.460E-06 | ALEACH( 7) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 7) |
| R017 | Inhalation rate (m**3/yr) | 7.300E+03 | 8.400E+03 | --- | INHALR |
| R017 | Mass loading for inhalation (g/m**3) | 1.000E-04 | 1.000E-04 | --- | MLINH |
| R017 | Exposure duration | 3.000E+01 | 3.000E+01 | --- | ED |
| R017 | Shielding factor, inhalation | 4.000E-01 | 4.000E-01 | --- | SHF3 |
| R017 | Shielding factor, external gamma | 8.000E-01 | 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 |

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Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.RAD

Site-Specific Parameter Summary (continued)

| 0 Menu | Parameter | User Input | Default | Used by RESRAD (If different from user input) | Parameter Name |
|---|---|---|---|---|---|
| R017 | Shape factor flag, external gamma | 1.000E+00 | 1.000E+00 | >0 shows circular AREA. | FS |
| R017 | Radii of shape factor array (used if FS = -1): | | | | |
| R017 | Outer annular radius (m), ring 1: | not used | 5.000E+01 | --- | RAD_SHAPE( 1) |
| R017 | Outer annular radius (m), ring 2: | not used | 7.071E+01 | --- | RAD_SHAPE( 2) |
| R017 | Outer annular radius (m), ring 3: | not used | 0.000E+00 | --- | RAD_SHAPE( 3) |
| R017 | Outer annular radius (m), ring 4: | not used | 0.000E+00 | --- | RAD_SHAPE( 4) |
| R017 | Outer annular radius (m), ring 5: | not used | 0.000E+00 | --- | RAD_SHAPE( 5) |
| R017 | Outer annular radius (m), ring 6: | not used | 0.000E+00 | --- | RAD_SHAPE( 6) |
| R017 | Outer annular radius (m), ring 7: | not used | 0.000E+00 | --- | RAD_SHAPE( 7) |
| R017 | Outer annular radius (m), ring 8: | not used | 0.000E+00 | --- | RAD_SHAPE( 8) |
| R017 | Outer annular radius (m), ring 9: | not used | 0.000E+00 | --- | RAD_SHAPE( 9) |
| R017 | Outer annular radius (m), ring 10: | not used | 0.000E+00 | --- | RAD_SHAPE(10) |
| R017 | Outer annular radius (m), ring 11: | not used | 0.000E+00 | --- | RAD_SHAPE(11) |
| R017 | Outer annular radius (m), ring 12: | not used | 0.000E+00 | --- | RAD_SHAPE(12) |
| R017 | Fractions of annular areas within AREA: | | | | |
| R017 | Ring 1 | not used | 1.000E+00 | --- | FRACA( 1) |
| R017 | Ring 2 | not used | 2.732E-01 | --- | FRACA( 2) |
| R017 | Ring 3 | not used | 0.000E+00 | --- | FRACA( 3) |
| R017 | Ring 4 | not used | 0.000E+00 | --- | FRACA( 4) |
| R017 | Ring 5 | not used | 0.000E+00 | --- | FRACA( 5) |
| R017 | Ring 6 | not used | 0.000E+00 | --- | FRACA( 6) |
| R017 | Ring 7 | not used | 0.000E+00 | --- | FRACA( 7) |
| R017 | Ring 8 | not used | 0.000E+00 | --- | FRACA( 8) |
| R017 | Ring 9 | not used | 0.000E+00 | --- | FRACA( 9) |
| R017 | Ring 10 | not used | 0.000E+00 | --- | FRACA(10) |
| R017 | Ring 11 | not used | 0.000E+00 | --- | FRACA(11) |
| R017 | Ring 12 | not used | 0.000E+00 | --- | FRACA(12) |
| R018 | Fruits, vegetables and grain consumption (kg/yr) | 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 | 0.100E+01 | FMEAT |
| R018 | Contamination fraction of milk | -1 | -1 | 0.100E+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 |

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Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.RAD

Site-Specific Parameter Summary (continued)

| 0 Menu | Parameter | User Input | Default | Used by RESRAD (If different from user input) | Parameter Name |
|---|---|---|---|---|---|
| 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) |
| 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) | 2.000E-05 | 2.000E-05 | --- | C12WTR |
| C14 | C-12 concentration in contaminated soil (g/g) | 3.000E-02 | 3.000E-02 | --- | C12CZ |
| C14 | Fraction of vegetation carbon from soil | 2.000E-02 | 2.000E-02 | --- | CSOIL |
| C14 | Fraction of vegetation carbon from air | 9.800E-01 | 9.800E-01 | --- | CAIR |
| C14 | C-14 evasion layer thickness in soil (m) | 3.000E-01 | 3.000E-01 | --- | DMC |
| C14 | C-14 evasion flux rate from soil (1/sec) | 7.000E-07 | 7.000E-07 | --- | EVSN |
| C14 | C-12 evasion flux rate from soil (1/sec) | 1.000E-10 | 1.000E-10 | --- | REVSN |
| C14 | Fraction of grain in beef cattle feed | 8.000E-01 | 8.000E-01 | --- | AVFG4 |
| C14 | Fraction of grain in milk cow feed | 2.000E-01 | 2.000E-01 | --- | AVFG5 |
| C14 | DCF correction factor for gaseous forms of C14 | 8.894E+01 | 8.894E+01 | --- | 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 |

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Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.RAD

Site-Specific Parameter Summary (continued)

| Menu | Parameter | User Input | Default | Used by RESRAD (If different from user input) | Parameter Name |
|---|---|---|---|---|---|
| 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 | 17 | --- | --- | LYMAX |
| TITL | Maximum number of integration points for risk | 257 | --- | --- | KYMAX |

Summary of Pathway Selections

| Pathway | User Selection |
|---|---|
| 1 -- external gamma | active |
| 2 -- inhalation (w/o radon) | active |
| 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 | active |

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 Summary : 116-F-1 Shallow Zone Radionuclides            File: 116-F-1_SZ_rad.RAD

      Contaminated Zone Dimensions              Initial Soil Concentrations, pCi/g
      ÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅ              ÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅ
        Area:  24817.00 square meters                C-14        1.470E+00
   Thickness:      6.40 meters                       Co-60       5.490E-02
 Cover Depth:      0.00 meters                       Cs-137      1.100E-01
                                                     Eu-152      1.770E-01
                                                     Eu-154      1.370E-01

0
                                   Total Dose TDOSE(t), mrem/yr
                             Basic Radiation Dose Limit = 1.500E+01 mrem/yr
                  Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)
                  ÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅÅ
   t (years):  0.000E+00  1.000E+00  3.000E+00  7.100E+00  1.500E+01  4.300E+01  1.000E+02  3.000E+02  1.000E+03
     TDOSE(t):  5.613E+00  3.315E+00  1.973E+00  1.373E+00  8.359E-01  2.130E-01  3.322E-02  2.957E-04  2.813E-11
        M(t):  3.742E-01  2.210E-01  1.315E-01  9.157E-02  5.572E-02  1.420E-02  2.215E-03  1.971E-05  1.875E-12
0Maximum TDOSE(t):  5.613E+00 mrem/yr   at t = 0.000E+00 years
```

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Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.RAD

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

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 8.221E-06 | 0.0000 | 4.888E-04 | 0.0001 | 0.000E+00 | 0.0000 | 1.879E+00 | 0.3347 | 8.238E-01 | 0.1468 | 6.385E-01 | 0.1138 | 1.117E-04 | 0.0000 |
| Co-60 | 5.390E-01 | 0.0960 | 4.995E-07 | 0.0000 | 0.000E+00 | 0.0000 | 6.238E-03 | 0.0011 | 5.918E-03 | 0.0011 | 1.356E-03 | 0.0002 | 8.081E-05 | 0.0000 |
| Cs-137 | 2.389E-01 | 0.0426 | 1.538E-07 | 0.0000 | 0.000E+00 | 0.0000 | 1.225E-02 | 0.0022 | 1.891E-02 | 0.0034 | 1.174E-02 | 0.0021 | 3.175E-04 | 0.0001 |
| Eu-152 | 7.812E-01 | 0.1392 | 1.690E-06 | 0.0000 | 0.000E+00 | 0.0000 | 1.575E-04 | 0.0000 | 5.394E-05 | 0.0000 | 1.425E-06 | 0.0000 | 6.527E-05 | 0.0000 |
| Eu-154 | 6.548E-01 | 0.1167 | 1.671E-06 | 0.0000 | 0.000E+00 | 0.0000 | 1.773E-04 | 0.0000 | 6.072E-05 | 0.0000 | 1.605E-06 | 0.0000 | 7.347E-05 | 0.0000 |
| Total | 2.214E+00 | 0.3944 | 4.928E-04 | 0.0001 | 0.000E+00 | 0.0000 | 1.897E+00 | 0.3381 | 8.487E-01 | 0.1512 | 6.516E-01 | 0.1161 | 6.487E-04 | 0.0001 |

0

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

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 | 3.342E+00 | 0.5953 |
| Co-60 | 1.255E-06 | 0.0000 | 1.537E-06 | 0.0000 | 0.000E+00 | 0.0000 | 1.188E-07 | 0.0000 | 2.129E-07 | 0.0000 | 1.133E-07 | 0.0000 | 5.526E-01 | 0.0984 |
| Cs-137 | 5.024E-06 | 0.0000 | 3.993E-05 | 0.0000 | 0.000E+00 | 0.0000 | 4.708E-07 | 0.0000 | 1.290E-06 | 0.0000 | 1.821E-06 | 0.0000 | 2.821E-01 | 0.0503 |
| 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 | 7.815E-01 | 0.1392 |
| Eu-154 | 0.000E+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 | 6.551E-01 | 0.1167 |
| Total | 6.279E-06 | 0.0000 | 4.147E-05 | 0.0000 | 0.000E+00 | 0.0000 | 5.895E-07 | 0.0000 | 1.503E-06 | 0.0000 | 1.934E-06 | 0.0000 | 5.613E+00 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/07/2003 11:35 Page 11
Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.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
0 Water Independent Pathways (Inhalation excludes radon)

| 0 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. |
| C-14 | 2.914E-06 | 0.0000 | 1.732E-04 | 0.0001 | 0.000E+00 | 0.0000 | 6.715E-01 | 0.2026 | 3.031E-01 | 0.0914 | 2.325E-01 | 0.0701 | 3.958E-05 | 0.0000 |
| Co-60 | 4.725E-01 | 0.1425 | 4.379E-07 | 0.0000 | 0.000E+00 | 0.0000 | 5.468E-03 | 0.0016 | 5.188E-03 | 0.0016 | 1.189E-03 | 0.0004 | 7.084E-05 | 0.0000 |
| Cs-137 | 2.334E-01 | 0.0704 | 1.503E-07 | 0.0000 | 0.000E+00 | 0.0000 | 1.197E-02 | 0.0036 | 1.847E-02 | 0.0056 | 1.147E-02 | 0.0035 | 3.102E-04 | 0.0001 |
| Eu-152 | 7.416E-01 | 0.2237 | 1.604E-06 | 0.0000 | 0.000E+00 | 0.0000 | 1.495E-04 | 0.0000 | 5.120E-05 | 0.0000 | 1.353E-06 | 0.0000 | 6.196E-05 | 0.0000 |
| Eu-154 | 6.052E-01 | 0.1826 | 1.544E-06 | 0.0000 | 0.000E+00 | 0.0000 | 1.639E-04 | 0.0000 | 5.612E-05 | 0.0000 | 1.483E-06 | 0.0000 | 6.791E-05 | 0.0000 |
| Total | 2.053E+00 | 0.6192 | 1.770E-04 | 0.0001 | 0.000E+00 | 0.0000 | 6.892E-01 | 0.2079 | 3.269E-01 | 0.0986 | 2.452E-01 | 0.0740 | 5.505E-04 | 0.0002 |

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
0 Water Dependent Pathways

| 0 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. |
| C-14 | 0.000E+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 | 1.207E+00 | 0.3642 |
| Co-60 | 3.378E-06 | 0.0000 | 4.355E-06 | 0.0000 | 0.000E+00 | 0.0000 | 3.583E-07 | 0.0000 | 1.212E-06 | 0.0000 | 4.190E-07 | 0.0000 | 4.844E-01 | 0.1461 |
| Cs-137 | 1.488E-05 | 0.0000 | 1.244E-04 | 0.0000 | 0.000E+00 | 0.0000 | 1.561E-06 | 0.0000 | 8.020E-06 | 0.0000 | 7.386E-06 | 0.0000 | 2.758E-01 | 0.0832 |
| 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 | 7.419E-01 | 0.2238 |
| Eu-154 | 0.000E+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 | 6.055E-01 | 0.1827 |
| Total | 1.826E-05 | 0.0000 | 1.288E-04 | 0.0000 | 0.000E+00 | 0.0000 | 1.919E-06 | 0.0000 | 9.232E-06 | 0.0000 | 7.805E-06 | 0.0000 | 3.315E+00 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/07/2003 11:35 Page 12
Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.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
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 3.656E-07 | 0.0000 | 2.174E-05 | 0.0000 | 0.000E+00 | 0.0000 | 8.426E-02 | 0.0427 | 3.804E-02 | 0.0193 | 2.917E-02 | 0.0148 | 4.966E-06 | 0.0000 |
| Co-60 | 3.631E-01 | 0.1840 | 3.365E-07 | 0.0000 | 0.000E+00 | 0.0000 | 4.202E-03 | 0.0021 | 3.987E-03 | 0.0020 | 9.136E-04 | 0.0005 | 5.444E-05 | 0.0000 |
| Cs-137 | 2.228E-01 | 0.1129 | 1.434E-07 | 0.0000 | 0.000E+00 | 0.0000 | 1.143E-02 | 0.0058 | 1.763E-02 | 0.0089 | 1.095E-02 | 0.0056 | 2.961E-04 | 0.0002 |
| Eu-152 | 6.683E-01 | 0.3387 | 1.446E-06 | 0.0000 | 0.000E+00 | 0.0000 | 1.347E-04 | 0.0001 | 4.614E-05 | 0.0000 | 1.219E-06 | 0.0000 | 5.584E-05 | 0.0000 |
| Eu-154 | 5.169E-01 | 0.2620 | 1.319E-06 | 0.0000 | 0.000E+00 | 0.0000 | 1.400E-04 | 0.0001 | 4.793E-05 | 0.0000 | 1.267E-06 | 0.0000 | 5.800E-05 | 0.0000 |
| Total | 1.771E+00 | 0.8977 | 2.498E-05 | 0.0000 | 0.000E+00 | 0.0000 | 1.002E-01 | 0.0508 | 5.975E-02 | 0.0303 | 4.104E-02 | 0.0208 | 4.693E-04 | 0.0002 |

0

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

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 | 1.515E-01 | 0.0768 |
| Co-60 | 6.102E-06 | 0.0000 | 8.004E-06 | 0.0000 | 0.000E+00 | 0.0000 | 6.721E-07 | 0.0000 | 2.728E-06 | 0.0000 | 8.406E-07 | 0.0000 | 3.723E-01 | 0.1887 |
| Cs-137 | 3.327E-05 | 0.0000 | 2.830E-04 | 0.0001 | 0.000E+00 | 0.0000 | 3.622E-06 | 0.0000 | 2.230E-05 | 0.0000 | 1.832E-05 | 0.0000 | 2.634E-01 | 0.1335 |
| 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 | 6.686E-01 | 0.3389 |
| Eu-154 | 0.000E+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 | 5.172E-01 | 0.2621 |
| Total | 3.937E-05 | 0.0000 | 2.910E-04 | 0.0001 | 0.000E+00 | 0.0000 | 4.294E-06 | 0.0000 | 2.503E-05 | 0.0000 | 1.916E-05 | 0.0000 | 1.973E+00 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/07/2003 11:35 Page 13
Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.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 = 7.100E+00 years
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 5.167E-09 | 0.0000 | 3.072E-07 | 0.0000 | 0.000E+00 | 0.0000 | 1.191E-03 | 0.0009 | 5.378E-04 | 0.0004 | 4.124E-04 | 0.0003 | 7.020E-08 | 0.0000 |
| Co-60 | 2.116E-01 | 0.1541 | 1.961E-07 | 0.0000 | 0.000E+00 | 0.0000 | 2.449E-03 | 0.0018 | 2.324E-03 | 0.0017 | 5.325E-04 | 0.0004 | 3.173E-05 | 0.0000 |
| Cs-137 | 2.025E-01 | 0.1474 | 1.304E-07 | 0.0000 | 0.000E+00 | 0.0000 | 1.039E-02 | 0.0076 | 1.603E-02 | 0.0117 | 9.956E-03 | 0.0072 | 2.692E-04 | 0.0002 |
| Eu-152 | 5.399E-01 | 0.3931 | 1.168E-06 | 0.0000 | 0.000E+00 | 0.0000 | 1.088E-04 | 0.0001 | 3.728E-05 | 0.0000 | 9.851E-07 | 0.0000 | 4.511E-05 | 0.0000 |
| Eu-154 | 3.742E-01 | 0.2724 | 9.547E-07 | 0.0000 | 0.000E+00 | 0.0000 | 1.013E-04 | 0.0001 | 3.470E-05 | 0.0000 | 9.170E-07 | 0.0000 | 4.199E-05 | 0.0000 |
| Total | 1.328E+00 | 0.9671 | 2.756E-06 | 0.0000 | 0.000E+00 | 0.0000 | 1.424E-02 | 0.0104 | 1.896E-02 | 0.0138 | 1.090E-02 | 0.0079 | 3.881E-04 | 0.0003 |

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 7.100E+00 years
0 Water Dependent Pathways

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 | 2.142E-03 | 0.0016 |
| Co-60 | 7.748E-06 | 0.0000 | 1.023E-05 | 0.0000 | 0.000E+00 | 0.0000 | 8.660E-07 | 0.0000 | 3.739E-06 | 0.0000 | 1.110E-06 | 0.0000 | 2.170E-01 | 0.1580 |
| Cs-137 | 6.580E-05 | 0.0000 | 5.636E-04 | 0.0004 | 0.000E+00 | 0.0000 | 7.267E-06 | 0.0000 | 4.758E-05 | 0.0000 | 3.768E-05 | 0.0000 | 2.399E-01 | 0.1746 |
| 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 | 5.401E-01 | 0.3932 |
| Eu-154 | 0.000E+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 | 3.744E-01 | 0.2726 |
| Total | 7.355E-05 | 0.0001 | 5.738E-04 | 0.0004 | 0.000E+00 | 0.0000 | 8.133E-06 | 0.0000 | 5.132E-05 | 0.0000 | 3.879E-05 | 0.0000 | 1.373E+00 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/07/2003 11:35 Page 14
Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.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 = 1.500E+01 years
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 1.388E-12 | 0.0000 | 8.255E-11 | 0.0000 | 0.000E+00 | 0.0000 | 3.200E-07 | 0.0000 | 1.445E-07 | 0.0000 | 1.109E-07 | 0.0000 | 1.886E-11 | 0.0000 |
| Co-60 | 7.480E-02 | 0.0895 | 6.932E-08 | 0.0000 | 0.000E+00 | 0.0000 | 8.657E-04 | 0.0010 | 8.213E-04 | 0.0010 | 1.882E-04 | 0.0002 | 1.121E-05 | 0.0000 |
| Cs-137 | 1.685E-01 | 0.2016 | 1.085E-07 | 0.0000 | 0.000E+00 | 0.0000 | 8.645E-03 | 0.0103 | 1.334E-02 | 0.0160 | 8.285E-03 | 0.0099 | 2.240E-04 | 0.0003 |
| Eu-152 | 3.579E-01 | 0.4282 | 7.743E-07 | 0.0000 | 0.000E+00 | 0.0000 | 7.216E-05 | 0.0001 | 2.471E-05 | 0.0000 | 6.531E-07 | 0.0000 | 2.990E-05 | 0.0000 |
| Eu-154 | 2.008E-01 | 0.2402 | 5.123E-07 | 0.0000 | 0.000E+00 | 0.0000 | 5.437E-05 | 0.0001 | 1.862E-05 | 0.0000 | 4.921E-07 | 0.0000 | 2.253E-05 | 0.0000 |
| Total | 8.020E-01 | 0.9595 | 1.464E-06 | 0.0000 | 0.000E+00 | 0.0000 | 9.637E-03 | 0.0115 | 1.420E-02 | 0.0170 | 8.474E-03 | 0.0101 | 2.876E-04 | 0.0003 |

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.500E+01 years
0 Water Dependent Pathways

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 | 5.755E-07 | 0.0000 |
| Co-60 | 5.596E-06 | 0.0000 | 7.413E-06 | 0.0000 | 0.000E+00 | 0.0000 | 6.294E-07 | 0.0000 | 2.786E-06 | 0.0000 | 8.150E-07 | 0.0000 | 7.670E-02 | 0.0918 |
| Cs-137 | 1.118E-04 | 0.0001 | 9.606E-04 | 0.0011 | 0.000E+00 | 0.0000 | 1.243E-05 | 0.0000 | 8.344E-05 | 0.0001 | 6.510E-05 | 0.0001 | 2.002E-01 | 0.2396 |
| 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 | 3.580E-01 | 0.4284 |
| Eu-154 | 0.000E+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 | 2.009E-01 | 0.2403 |
| Total | 1.174E-04 | 0.0001 | 9.680E-04 | 0.0012 | 0.000E+00 | 0.0000 | 1.306E-05 | 0.0000 | 8.622E-05 | 0.0001 | 6.591E-05 | 0.0001 | 8.359E-01 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/07/2003 11:35 Page 15
Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.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
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 2.601E-25 | 0.0000 | 1.546E-23 | 0.0000 | 0.000E+00 | 0.0000 | 5.998E-20 | 0.0000 | 2.712E-20 | 0.0000 | 2.079E-20 | 0.0000 | 3.533E-24 | 0.0000 |
| Co-60 | 1.875E-03 | 0.0088 | 1.737E-09 | 0.0000 | 0.000E+00 | 0.0000 | 2.170E-05 | 0.0001 | 2.058E-05 | 0.0001 | 4.717E-06 | 0.0000 | 2.811E-07 | 0.0000 |
| Cs-137 | 8.786E-02 | 0.4125 | 5.657E-08 | 0.0000 | 0.000E+00 | 0.0000 | 4.507E-03 | 0.0212 | 6.954E-03 | 0.0326 | 4.319E-03 | 0.0203 | 1.168E-04 | 0.0005 |
| Eu-152 | 8.337E-02 | 0.3914 | 1.803E-07 | 0.0000 | 0.000E+00 | 0.0000 | 1.681E-05 | 0.0001 | 5.756E-06 | 0.0000 | 1.521E-07 | 0.0000 | 6.965E-06 | 0.0000 |
| Eu-154 | 2.210E-02 | 0.1038 | 5.639E-08 | 0.0000 | 0.000E+00 | 0.0000 | 5.985E-06 | 0.0000 | 2.049E-06 | 0.0000 | 5.416E-08 | 0.0000 | 2.480E-06 | 0.0000 |
| Total | 1.952E-01 | 0.9164 | 2.950E-07 | 0.0000 | 0.000E+00 | 0.0000 | 4.552E-03 | 0.0214 | 6.983E-03 | 0.0328 | 4.324E-03 | 0.0203 | 1.265E-04 | 0.0006 |

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.300E+01 years
0 Water Dependent Pathways

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 | 1.079E-19 | 0.0000 |
| Co-60 | 3.949E-07 | 0.0000 | 5.242E-07 | 0.0000 | 0.000E+00 | 0.0000 | 4.460E-08 | 0.0000 | 2.004E-07 | 0.0000 | 5.811E-08 | 0.0000 | 1.923E-03 | 0.0090 |
| Cs-137 | 1.641E-04 | 0.0008 | 1.413E-03 | 0.0066 | 0.000E+00 | 0.0000 | 1.831E-05 | 0.0001 | 1.248E-04 | 0.0006 | 9.651E-05 | 0.0005 | 1.056E-01 | 0.4956 |
| 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 | 8.340E-02 | 0.3915 |
| Eu-154 | 0.000E+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 | 2.211E-02 | 0.1038 |
| Total | 1.645E-04 | 0.0008 | 1.413E-03 | 0.0066 | 0.000E+00 | 0.0000 | 1.836E-05 | 0.0001 | 1.250E-04 | 0.0006 | 9.657E-05 | 0.0005 | 2.130E-01 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/07/2003 11:35 Page 16
Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 |
| Co-60 | 1.032E-06 | 0.0000 | 9.566E-13 | 0.0000 | 0.000E+00 | 0.0000 | 1.195E-08 | 0.0000 | 1.133E-08 | 0.0000 | 2.597E-09 | 0.0000 | 1.548E-10 | 0.0000 |
| Cs-137 | 2.333E-02 | 0.7024 | 1.502E-08 | 0.0000 | 0.000E+00 | 0.0000 | 1.197E-03 | 0.0360 | 1.847E-03 | 0.0556 | 1.147E-03 | 0.0345 | 3.101E-05 | 0.0009 |
| Eu-152 | 4.293E-03 | 0.1292 | 9.288E-09 | 0.0000 | 0.000E+00 | 0.0000 | 8.655E-07 | 0.0000 | 2.964E-07 | 0.0000 | 7.834E-09 | 0.0000 | 3.587E-07 | 0.0000 |
| Eu-154 | 2.475E-04 | 0.0075 | 6.315E-10 | 0.0000 | 0.000E+00 | 0.0000 | 6.702E-08 | 0.0000 | 2.295E-08 | 0.0000 | 6.066E-10 | 0.0000 | 2.777E-08 | 0.0000 |
| Total | 2.788E-02 | 0.8391 | 2.494E-08 | 0.0000 | 0.000E+00 | 0.0000 | 1.198E-03 | 0.0361 | 1.847E-03 | 0.0556 | 1.147E-03 | 0.0345 | 3.140E-05 | 0.0009 |

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
0 Water Dependent Pathways

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 |
| Co-60 | 5.053E-10 | 0.0000 | 6.711E-10 | 0.0000 | 0.000E+00 | 0.0000 | 5.713E-11 | 0.0000 | 2.579E-10 | 0.0000 | 7.458E-11 | 0.0000 | 1.060E-06 | 0.0000 |
| Cs-137 | 1.013E-04 | 0.0030 | 8.721E-04 | 0.0263 | 0.000E+00 | 0.0000 | 1.131E-05 | 0.0003 | 7.746E-05 | 0.0023 | 5.974E-05 | 0.0018 | 2.868E-02 | 0.8632 |
| 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 | 4.295E-03 | 0.1293 |
| Eu-154 | 0.000E+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 | 2.476E-04 | 0.0075 |
| Total | 1.013E-04 | 0.0030 | 8.721E-04 | 0.0263 | 0.000E+00 | 0.0000 | 1.131E-05 | 0.0003 | 7.746E-05 | 0.0023 | 5.974E-05 | 0.0018 | 3.322E-02 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T« Limit = 0.5 year 03/07/2003 11:35 Page 17
Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.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
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 |
| Co-60 | 3.785E-18 | 0.0000 | 3.508E-24 | 0.0000 | 0.000E+00 | 0.0000 | 4.381E-20 | 0.0000 | 4.157E-20 | 0.0000 | 9.524E-21 | 0.0000 | 5.675E-22 | 0.0000 |
| Cs-137 | 2.226E-04 | 0.7529 | 1.433E-10 | 0.0000 | 0.000E+00 | 0.0000 | 1.142E-05 | 0.0386 | 1.762E-05 | 0.0596 | 1.095E-05 | 0.0370 | 2.959E-07 | 0.0010 |
| Eu-152 | 1.297E-07 | 0.0004 | 2.806E-13 | 0.0000 | 0.000E+00 | 0.0000 | 2.614E-11 | 0.0000 | 8.952E-12 | 0.0000 | 2.366E-13 | 0.0000 | 1.083E-11 | 0.0000 |
| Eu-154 | 3.537E-11 | 0.0000 | 9.024E-17 | 0.0000 | 0.000E+00 | 0.0000 | 9.577E-15 | 0.0000 | 3.280E-15 | 0.0000 | 8.668E-17 | 0.0000 | 3.969E-15 | 0.0000 |
| Total | 2.228E-04 | 0.7533 | 1.436E-10 | 0.0000 | 0.000E+00 | 0.0000 | 1.142E-05 | 0.0386 | 1.762E-05 | 0.0596 | 1.095E-05 | 0.0370 | 2.959E-07 | 0.0010 |

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years
0 Water Dependent Pathways

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 |
| Co-60 | 5.651E-21 | 0.0000 | 7.507E-21 | 0.0000 | 0.000E+00 | 0.0000 | 6.393E-22 | 0.0000 | 2.893E-21 | 0.0000 | 8.354E-22 | 0.0000 | 3.898E-18 | 0.0000 |
| Cs-137 | 2.946E-06 | 0.0100 | 2.538E-05 | 0.0858 | 0.000E+00 | 0.0000 | 3.294E-07 | 0.0011 | 2.260E-06 | 0.0076 | 1.741E-06 | 0.0059 | 2.956E-04 | 0.9996 |
| 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 | 1.297E-07 | 0.0004 |
| Eu-154 | 0.000E+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 | 3.539E-11 | 0.0000 |
| Total | 2.946E-06 | 0.0100 | 2.538E-05 | 0.0858 | 0.000E+00 | 0.0000 | 3.294E-07 | 0.0011 | 2.260E-06 | 0.0076 | 1.741E-06 | 0.0059 | 2.957E-04 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/07/2003 11:35 Page 18
Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.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- | 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. |
| C-14 | 0.000E+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 |
| Co-60 | 0.000E+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 |
| Cs-137 | 1.889E-11 | 0.6715 | 1.216E-17 | 0.0000 | 0.000E+00 | 0.0000 | 9.690E-13 | 0.0344 | 1.495E-12 | 0.0532 | 9.287E-13 | 0.0330 | 2.511E-14 | 0.0009 |
| Eu-152 | 1.963E-23 | 0.0000 | 6.506E-17 | 0.0000 | 0.000E+00 | 0.0000 | 1.370E-16 | 0.0000 | 4.692E-17 | 0.0000 | 1.240E-18 | 0.0000 | 5.678E-17 | 0.0000 |
| Eu-154 | 0.000E+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 | 1.889E-11 | 0.6715 | 7.722E-17 | 0.0000 | 0.000E+00 | 0.0000 | 9.691E-13 | 0.0345 | 1.495E-12 | 0.0532 | 9.287E-13 | 0.0330 | 2.516E-14 | 0.0009 |

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- | 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. |
| C-14 | 0.000E+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 |
| Co-60 | 0.000E+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 |
| Cs-137 | 5.252E-13 | 0.0187 | 4.525E-12 | 0.1608 | 0.000E+00 | 0.0000 | 5.873E-14 | 0.0021 | 4.035E-13 | 0.0143 | 3.106E-13 | 0.0110 | 2.813E-11 | 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 | 3.070E-16 | 0.0000 |
| Eu-154 | 0.000E+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 | 5.252E-13 | 0.0187 | 4.525E-12 | 0.1608 | 0.000E+00 | 0.0000 | 5.873E-14 | 0.0021 | 4.035E-13 | 0.0143 | 3.106E-13 | 0.0110 | 2.813E-11 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T« Limit = 0.5 year 03/07/2003 11:35 Page 19
Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.RAD

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

| 0Parent (i) | Product (j) | Branch Fraction* | DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00 | 1.000E+00 | 3.000E+00 | 7.100E+00 | 1.500E+01 | 4.300E+01 | 1.000E+02 | 3.000E+02 | 1.000E+03 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C-14 | C-14 | 1.000E+00 | 2.273E+00 | 8.213E-01 | 1.031E-01 | 1.457E-03 | 3.915E-07 | 7.341E-20 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 0Co-60 | Co-60 | 1.000E+00 | 1.006E+01 | 8.823E+00 | 6.781E+00 | 3.953E+00 | 1.397E+00 | 3.503E-02 | 1.930E-05 | 7.100E-17 | 0.000E+00 |
| 0Cs-137 | Cs-137 | 1.000E+00 | 2.565E+00 | 2.507E+00 | 2.395E+00 | 2.181E+00 | 1.820E+00 | 9.598E-01 | 2.607E-01 | 2.687E-03 | 2.557E-10 |
| 0Eu-152 | Eu-152 | 7.208E-01 | 3.183E+00 | 3.021E+00 | 2.723E+00 | 2.199E+00 | 1.458E+00 | 3.396E-01 | 1.749E-02 | 5.282E-07 | 7.997E-23 |
| 0Eu-152 | Eu-152 | 2.792E-01 | 1.233E+00 | 1.170E+00 | 1.055E+00 | 8.520E-01 | 5.648E-01 | 1.315E-01 | 6.775E-03 | 2.046E-07 | 3.098E-23 |
| Eu-152 | Gd-152 | 2.792E-01 | 4.477E-17 | 1.313E-16 | 2.913E-16 | 5.717E-16 | 9.690E-16 | 1.568E-15 | 1.740E-15 | 1.746E-15 | 1.734E-15 |
| Eu-152 | åDSR(j) | | 1.233E+00 | 1.170E+00 | 1.055E+00 | 8.520E-01 | 5.648E-01 | 1.315E-01 | 6.775E-03 | 2.046E-07 | 1.734E-15 |
| 0Eu-154 | Eu-154 | 1.000E+00 | 4.782E+00 | 4.419E+00 | 3.775E+00 | 2.733E+00 | 1.466E+00 | 1.614E-01 | 1.808E-03 | 2.583E-10 | 2.849E-34 |

*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life ó 0.5 yr) daughters.
0

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 1.500E+01 mrem/yr

| 0Nuclide (i) | t= 0.000E+00 | 1.000E+00 | 3.000E+00 | 7.100E+00 | 1.500E+01 | 4.300E+01 | 1.000E+02 | 3.000E+02 | 1.000E+03 |
|---|---|---|---|---|---|---|---|---|---|
| C-14 | 6.599E+00 | 1.826E+01 | 1.455E+02 | 1.030E+04 | 3.831E+07 | *4.454E+12 | *4.454E+12 | *4.454E+12 | *4.454E+12 |
| Co-60 | 1.490E+00 | 1.700E+00 | 2.212E+00 | 3.795E+00 | 1.074E+01 | 4.282E+02 | 7.771E+05 | *1.131E+15 | *1.131E+15 |
| Cs-137 | 5.848E+00 | 5.983E+00 | 6.263E+00 | 6.879E+00 | 8.240E+00 | 1.563E+01 | 5.754E+01 | 5.582E+03 | 5.866E+10 |
| Eu-152 | 3.397E+00 | 3.579E+00 | 3.971E+00 | 4.916E+00 | 7.415E+00 | 3.184E+01 | 6.182E+02 | 2.047E+07 | *1.765E+14 |
| Eu-154 | 3.137E+00 | 3.394E+00 | 3.974E+00 | 5.489E+00 | 1.023E+01 | 9.293E+01 | 8.298E+03 | 5.807E+10 | *2.639E+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 = 0.000E+00 years

| 0Nuclide (i) | Initial (pCi/g) | tmin (years) | DSR(i,tmin) | G(i,tmin) (pCi/g) | DSR(i,tmax) | G(i,tmax) (pCi/g) |
|---|---|---|---|---|---|---|
| C-14 | 1.470E+00 | 0.000E+00 | 2.273E+00 | 6.599E+00 | 2.273E+00 | 6.599E+00 |
| Co-60 | 5.490E-02 | 0.000E+00 | 1.006E+01 | 1.490E+00 | 1.006E+01 | 1.490E+00 |
| Cs-137 | 1.100E-01 | 0.000E+00 | 2.565E+00 | 5.848E+00 | 2.565E+00 | 5.848E+00 |
| Eu-152 | 1.770E-01 | 0.000E+00 | 4.415E+00 | 3.397E+00 | 4.415E+00 | 3.397E+00 |
| Eu-154 | 1.370E-01 | 0.000E+00 | 4.782E+00 | 3.137E+00 | 4.782E+00 | 3.137E+00 |

1RESRAD, Version 6.21 T« Limit = 0.5 year 03/07/2003 11:35 Page 20
Summary : 116-F-1 Shallow Zone Radionuclides File: 116-F-1_SZ_rad.RAD

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

| 0Nuclide (j) | Parent (i) | BRF(i) | DOSE(j,t), mrem/yr t= 0.000E+00 | 1.000E+00 | 3.000E+00 | 7.100E+00 | 1.500E+01 | 4.300E+01 | 1.000E+02 | 3.000E+02 | 1.000E+03 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C-14 | C-14 | 1.000E+00 | 3.342E+00 | 1.207E+00 | 1.515E-01 | 2.142E-03 | 5.755E-07 | 1.079E-19 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 0Co-60 | Co-60 | 1.000E+00 | 5.526E-01 | 4.844E-01 | 3.723E-01 | 2.170E-01 | 7.670E-02 | 1.923E-03 | 1.060E-06 | 3.898E-18 | 0.000E+00 |
| 0Cs-137 | Cs-137 | 1.000E+00 | 2.821E-01 | 2.758E-01 | 2.634E-01 | 2.399E-01 | 2.002E-01 | 1.056E-01 | 2.868E-02 | 2.956E-04 | 2.813E-11 |
| 0Eu-152 | Eu-152 | 7.208E-01 | 5.633E-01 | 5.348E-01 | 4.819E-01 | 3.893E-01 | 2.581E-01 | 6.011E-02 | 3.096E-03 | 9.350E-08 | 1.416E-23 |
| Eu-152 | Eu-152 | 2.792E-01 | 2.182E-01 | 2.071E-01 | 1.867E-01 | 1.508E-01 | 9.997E-02 | 2.328E-02 | 1.199E-03 | 3.622E-08 | 5.483E-24 |
| Eu-152 | ÃDOSE(j) | | 7.815E-01 | 7.419E-01 | 6.686E-01 | 5.401E-01 | 3.580E-01 | 8.340E-02 | 4.295E-03 | 1.297E-07 | 1.964E-23 |
| 0Gd-152 | Eu-152 | 2.792E-01 | 7.924E-18 | 2.323E-17 | 5.157E-17 | 1.012E-16 | 1.715E-16 | 2.776E-16 | 3.080E-16 | 3.090E-16 | 3.070E-16 |
| 0Eu-154 | Eu-154 | 1.000E+00 | 6.551E-01 | 6.055E-01 | 5.172E-01 | 3.744E-01 | 2.009E-01 | 2.211E-02 | 2.476E-04 | 3.539E-11 | 0.000E+00 |

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

| 0Nuclide (j) | Parent (i) | BRF(i) | S(j,t), pCi/g t= 0.000E+00 | 1.000E+00 | 3.000E+00 | 7.100E+00 | 1.500E+01 | 4.300E+01 | 1.000E+02 | 3.000E+02 | 1.000E+03 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C-14 | C-14 | 1.000E+00 | 1.470E+00 | 5.210E-01 | 6.540E-02 | 9.249E-04 | 2.488E-07 | 4.678E-20 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 0Co-60 | Co-60 | 1.000E+00 | 5.490E-02 | 4.813E-02 | 3.699E-02 | 2.156E-02 | 7.619E-03 | 1.909E-04 | 1.051E-07 | 3.856E-19 | 0.000E+00 |
| 0Cs-137 | Cs-137 | 1.000E+00 | 1.100E-01 | 1.075E-01 | 1.026E-01 | 9.325E-02 | 7.760E-02 | 4.046E-02 | 1.074E-02 | 1.025E-04 | 8.698E-12 |
| 0Eu-152 | Eu-152 | 7.208E-01 | 1.276E-01 | 1.211E-01 | 1.091E-01 | 8.817E-02 | 5.845E-02 | 1.361E-02 | 7.011E-04 | 2.118E-08 | 3.206E-24 |
| Eu-152 | Eu-152 | 2.792E-01 | 4.942E-02 | 4.691E-02 | 4.228E-02 | 3.415E-02 | 2.264E-02 | 5.273E-03 | 2.716E-04 | 8.202E-09 | 1.242E-24 |
| Eu-152 | ÃS(j): | | 1.770E-01 | 1.680E-01 | 1.514E-01 | 1.223E-01 | 8.109E-02 | 1.889E-02 | 9.727E-04 | 2.938E-08 | 4.448E-24 |
| 0Gd-152 | Eu-152 | 2.792E-01 | 0.000E+00 | 3.091E-16 | 8.809E-16 | 1.883E-15 | 3.302E-15 | 5.443E-15 | 6.057E-15 | 6.079E-15 | 6.039E-15 |
| 0Eu-154 | Eu-154 | 1.000E+00 | 1.370E-01 | 1.266E-01 | 1.082E-01 | 7.829E-02 | 4.201E-02 | 4.624E-03 | 5.179E-05 | 7.400E-12 | 8.163E-36 |

BRF(i) is the branch fraction of the parent nuclide.
0RESCALC.EXE execution time = 4.51 seconds

# RESRAD INPUT PARAMETERS FOR THE OVERBURDEN

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Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.RAD

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

| 0 Menu | Parameter | Current Value | Default | Parameter Name |
|---|---|---|---|---|
| B-1 | Dose conversion factors for inhalation, mrem/pCi: | | | |
| B-1 | C-14 | 2.090E-06 | 2.090E-06 | DCF2( 1) |
| B-1 | Co-60 | 2.190E-04 | 2.190E-04 | DCF2( 2) |
| B-1 | Cs-137+D | 3.190E-05 | 3.190E-05 | DCF2( 3) |
| B-1 | Eu-152 | 2.210E-04 | 2.210E-04 | DCF2( 4) |
| B-1 | Eu-154 | 2.860E-04 | 2.860E-04 | DCF2( 6) |
| B-1 | Gd-152 | 2.430E-01 | 2.430E-01 | DCF2( 7) |
| D-1 | Dose conversion factors for ingestion, mrem/pCi: | | | |
| D-1 | C-14 | 2.090E-06 | 2.090E-06 | DCF3( 1) |
| D-1 | Co-60 | 2.690E-05 | 2.690E-05 | DCF3( 2) |
| D-1 | Cs-137+D | 5.000E-05 | 5.000E-05 | DCF3( 3) |
| D-1 | Eu-152 | 6.480E-06 | 6.480E-06 | DCF3( 4) |
| D-1 | Eu-154 | 9.550E-06 | 9.550E-06 | DCF3( 6) |
| D-1 | Gd-152 | 1.610E-04 | 1.610E-04 | DCF3( 7) |
| D-34 | Food transfer factors: | | | |
| D-34 | C-14 , plant/soil concentration ratio, dimensionless | 5.500E+00 | 5.500E+00 | RTF( 1,1) |
| D-34 | C-14 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 3.100E-02 | 3.100E-02 | RTF( 1,2) |
| D-34 | C-14 , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 1.200E-02 | 1.200E-02 | RTF( 1,3) |
| D-34 | Co-60 , plant/soil concentration ratio, dimensionless | 8.000E-02 | 8.000E-02 | RTF( 2,1) |
| D-34 | Co-60 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 2.000E-02 | 2.000E-02 | RTF( 2,2) |
| D-34 | Co-60 , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 2.000E-03 | 2.000E-03 | RTF( 2,3) |
| D-34 | Cs-137+D , plant/soil concentration ratio, dimensionless | 4.000E-02 | 4.000E-02 | RTF( 3,1) |
| D-34 | Cs-137+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 3.000E-02 | 3.000E-02 | RTF( 3,2) |
| D-34 | Cs-137+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 8.000E-03 | 8.000E-03 | RTF( 3,3) |
| D-34 | Eu-152 , plant/soil concentration ratio, dimensionless | 2.500E-03 | 2.500E-03 | RTF( 4,1) |
| D-34 | Eu-152 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 2.000E-03 | 2.000E-03 | RTF( 4,2) |
| D-34 | Eu-152 , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 2.000E-05 | 2.000E-05 | RTF( 4,3) |
| D-34 | Eu-154 , plant/soil concentration ratio, dimensionless | 2.500E-03 | 2.500E-03 | RTF( 6,1) |
| D-34 | Eu-154 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 2.000E-03 | 2.000E-03 | RTF( 6,2) |
| D-34 | Eu-154 , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 2.000E-05 | 2.000E-05 | RTF( 6,3) |
| D-34 | Gd-152 , plant/soil concentration ratio, dimensionless | 2.500E-03 | 2.500E-03 | RTF( 7,1) |
| D-34 | Gd-152 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d) | 2.000E-03 | 2.000E-03 | RTF( 7,2) |
| D-34 | Gd-152 , milk/livestock-intake ratio, (pCi/L)/(pCi/d) | 2.000E-05 | 2.000E-05 | RTF( 7,3) |
| D-5 | Bioaccumulation factors, fresh water, L/kg: | | | |
| D-5 | C-14 , fish | 5.000E+04 | 5.000E+04 | BIOFAC( 1,1) |
| D-5 | C-14 , crustacea and mollusks | 9.100E+03 | 9.100E+03 | BIOFAC( 1,2) |
| D-5 | Co-60 , fish | 3.000E+02 | 3.000E+02 | BIOFAC( 2,1) |
| D-5 | Co-60 , crustacea and mollusks | 2.000E+02 | 2.000E+02 | BIOFAC( 2,2) |
| D-5 | Cs-137+D , fish | 2.000E+03 | 2.000E+03 | BIOFAC( 3,1) |
| D-5 | Cs-137+D , crustacea and mollusks | 1.000E+02 | 1.000E+02 | BIOFAC( 3,2) |

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Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.RAD

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

| 0 Menu | Parameter | Current Value | Default | Parameter Name |
|---|---|---|---|---|
| D-5 | Eu-152 , fish | 5.000E+01 | 5.000E+01 | BIOFAC( 4,1) |
| D-5 | Eu-152 , crustacea and mollusks | 1.000E+03 | 1.000E+03 | BIOFAC( 4,2) |
| D-5 | | | | |
| D-5 | Eu-154 , fish | 5.000E+01 | 5.000E+01 | BIOFAC( 6,1) |
| D-5 | Eu-154 , crustacea and mollusks | 1.000E+03 | 1.000E+03 | BIOFAC( 6,2) |
| D-5 | | | | |
| D-5 | Gd-152 , fish | 2.500E+01 | 2.500E+01 | BIOFAC( 7,1) |
| D-5 | Gd-152 , crustacea and mollusks | 1.000E+03 | 1.000E+03 | BIOFAC( 7,2) |

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Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.RAD

Site-Specific Parameter Summary

| 0 Menu | Parameter | User Input | Default | Used by RESRAD (If different from user input) | Parameter Name |
|---|---|---|---|---|---|
| R011 | Area of contaminated zone (m**2) | 2.482E+04 | 1.000E+04 | --- | AREA |
| R011 | Thickness of contaminated zone (m) | 4.500E+00 | 2.000E+00 | --- | THICK0 |
| R011 | Length parallel to aquifer flow (m) | 3.100E+01 | 1.000E+02 | --- | LCZPAQ |
| R011 | Basic radiation dose limit (mrem/yr) | 1.500E+01 | 2.500E+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) | 7.100E+00 | 1.000E+01 | --- | T( 4) |
| R011 | Times for calculations (yr) | 1.500E+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): C-14 | 6.330E-01 | 0.000E+00 | --- | S1( 1) |
| R012 | Initial principal radionuclide (pCi/g): Co-60 | 1.620E-02 | 0.000E+00 | --- | S1( 2) |
| R012 | Initial principal radionuclide (pCi/g): Eu-152 | 5.240E-02 | 0.000E+00 | --- | S1( 4) |
| R012 | Initial principal radionuclide (pCi/g): Eu-154 | 4.910E-02 | 0.000E+00 | --- | S1( 6) |
| R012 | Concentration in groundwater (pCi/L): C-14 | not used | 0.000E+00 | --- | W1( 1) |
| R012 | Concentration in groundwater (pCi/L): Co-60 | not used | 0.000E+00 | --- | W1( 2) |
| R012 | Concentration in groundwater (pCi/L): Eu-152 | not used | 0.000E+00 | --- | W1( 4) |
| R012 | Concentration in groundwater (pCi/L): Eu-154 | not used | 0.000E+00 | --- | W1( 6) |
| | | | | | |
| R013 | Cover depth (m) | 0.000E+00 | 0.000E+00 | --- | COVER0 |
| R013 | Density of cover material (g/cm**3) | not used | 1.500E+00 | --- | DENSCV |
| R013 | Cover depth erosion rate (m/yr) | not used | 1.000E-03 | --- | VCV |
| R013 | Density of contaminated zone (g/cm**3) | 1.600E+00 | 1.500E+00 | --- | DENSCZ |
| R013 | Contaminated zone erosion rate (m/yr) | 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 |

Site-Specific Parameter Summary (continued)

| 0 Menu | Parameter | User Input | Default | Used by RESRAD (If different from user input) | Parameter Name |
|---|---|---|---|---|---|
| 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 |
| R015 | Number of unsaturated zone strata | 1 | 1 | --- | NS |
| R015 | Unsat. zone 1, thickness (m) | 1.900E+00 | 4.000E+00 | --- | H(1) |
| R015 | Unsat. zone 1, soil density (g/cm**3) | 1.600E+00 | 1.500E+00 | --- | DENSUZ(1) |
| R015 | Unsat. zone 1, total porosity | 4.000E-01 | 4.000E-01 | --- | TPUZ(1) |
| R015 | Unsat. zone 1, effective porosity | 2.500E-01 | 2.000E-01 | --- | EPUZ(1) |
| R015 | Unsat. zone 1, field capacity | 1.500E-01 | 2.000E-01 | --- | FCUZ(1) |
| R015 | Unsat. zone 1, soil-specific b parameter | 4.050E+00 | 5.300E+00 | --- | BUZ(1) |
| R015 | Unsat. zone 1, hydraulic conductivity (m/yr) | 2.500E+02 | 1.000E+01 | --- | HCUZ(1) |
| R016 | Distribution coefficients for C-14 | | | | |
| R016 | Contaminated zone (cm**3/g) | 2.000E+02 | 0.000E+00 | --- | DCNUCC( 1) |
| R016 | Unsaturated zone 1 (cm**3/g) | 2.000E+02 | 0.000E+00 | --- | DCNUCU( 1,1) |
| R016 | Saturated zone (cm**3/g) | 2.000E+02 | 0.000E+00 | --- | DCNUCS( 1) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 5.547E-05 | ALEACH( 1) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 1) |
| R016 | Distribution coefficients for Co-60 | | | | |
| R016 | Contaminated zone (cm**3/g) | 5.000E+01 | 1.000E+03 | --- | DCNUCC( 2) |
| R016 | Unsaturated zone 1 (cm**3/g) | 5.000E+01 | 1.000E+03 | --- | DCNUCU( 2,1) |
| R016 | Saturated zone (cm**3/g) | 5.000E+01 | 1.000E+03 | --- | DCNUCS( 2) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 2.215E-04 | ALEACH( 2) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 2) |
| R016 | Distribution coefficients for Eu-152 | | | | |
| R016 | Contaminated zone (cm**3/g) | 2.000E+02 | -1.000E+00 | --- | DCNUCC( 4) |
| R016 | Unsaturated zone 1 (cm**3/g) | 2.000E+02 | -1.000E+00 | --- | DCNUCU( 4,1) |
| R016 | Saturated zone (cm**3/g) | 2.000E+02 | -1.000E+00 | --- | DCNUCS( 4) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 5.547E-05 | ALEACH( 4) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 4) |
| R016 | Distribution coefficients for Eu-154 | | | | |
| R016 | Contaminated zone (cm**3/g) | 2.000E+02 | -1.000E+00 | --- | DCNUCC( 6) |
| R016 | Unsaturated zone 1 (cm**3/g) | 2.000E+02 | -1.000E+00 | --- | DCNUCU( 6,1) |
| R016 | Saturated zone (cm**3/g) | 2.000E+02 | -1.000E+00 | --- | DCNUCS( 6) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 5.547E-05 | ALEACH( 6) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 6) |
| R016 | Distribution coefficients for daughter Cs-137 | | | | |
| R016 | Contaminated zone (cm**3/g) | 5.000E+01 | 1.000E+03 | --- | DCNUCC( 3) |
| R016 | Unsaturated zone 1 (cm**3/g) | 5.000E+01 | 1.000E+03 | --- | DCNUCU( 3,1) |
| R016 | Saturated zone (cm**3/g) | 5.000E+01 | 1.000E+03 | --- | DCNUCS( 3) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 2.215E-04 | ALEACH( 3) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 3) |

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Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.RAD

Site-Specific Parameter Summary (continued)

| 0 Menu | Parameter | User Input | Default | Used by RESRAD (If different from user input) | Parameter Name |
|---|---|---|---|---|---|
| R016 | Distribution coefficients for daughter Gd-152 | | | | |
| R016 | Contaminated zone (cm**3/g) | -1.000E+00 | -1.000E+00 | 8.249E+02 | DCNUCC( 7) |
| R016 | Unsaturated zone 1 (cm**3/g) | -1.000E+00 | -1.000E+00 | 8.249E+02 | DCNUCU( 7,1) |
| R016 | Saturated zone (cm**3/g) | -1.000E+00 | -1.000E+00 | 8.249E+02 | DCNUCS( 7) |
| R016 | Leach rate (/yr) | 0.000E+00 | 0.000E+00 | 1.345E-05 | ALEACH( 7) |
| R016 | Solubility constant | 0.000E+00 | 0.000E+00 | not used | SOLUBK( 7) |
| | | | | | |
| R017 | Inhalation rate (m**3/yr) | 7.300E+03 | 8.400E+03 | --- | INHALR |
| R017 | Mass loading for inhalation (g/m**3) | 1.000E-04 | 1.000E-04 | --- | MLINH |
| R017 | Exposure duration | 3.000E+01 | 3.000E+01 | --- | ED |
| R017 | Shielding factor, inhalation | 4.000E-01 | 4.000E-01 | --- | SHF3 |
| R017 | Shielding factor, external gamma | 8.000E-01 | 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 | 1.000E+00 | 1.000E+00 | >0 shows circular AREA. | FS |
| R017 | Radii of shape factor array (used if FS = -1): | | | | |
| R017 | Outer annular radius (m), ring 1: | not used | 5.000E+01 | --- | RAD_SHAPE( 1) |
| R017 | Outer annular radius (m), ring 2: | not used | 7.071E+01 | --- | RAD_SHAPE( 2) |
| R017 | Outer annular radius (m), ring 3: | not used | 0.000E+00 | --- | RAD_SHAPE( 3) |
| R017 | Outer annular radius (m), ring 4: | not used | 0.000E+00 | --- | RAD_SHAPE( 4) |
| R017 | Outer annular radius (m), ring 5: | not used | 0.000E+00 | --- | RAD_SHAPE( 5) |
| R017 | Outer annular radius (m), ring 6: | not used | 0.000E+00 | --- | RAD_SHAPE( 6) |
| R017 | Outer annular radius (m), ring 7: | not used | 0.000E+00 | --- | RAD_SHAPE( 7) |
| R017 | Outer annular radius (m), ring 8: | not used | 0.000E+00 | --- | RAD_SHAPE( 8) |
| R017 | Outer annular radius (m), ring 9: | not used | 0.000E+00 | --- | RAD_SHAPE( 9) |
| R017 | Outer annular radius (m), ring 10: | not used | 0.000E+00 | --- | RAD_SHAPE(10) |
| R017 | Outer annular radius (m), ring 11: | not used | 0.000E+00 | --- | RAD_SHAPE(11) |
| R017 | Outer annular radius (m), ring 12: | not used | 0.000E+00 | --- | RAD_SHAPE(12) |
| | | | | | |
| R017 | Fractions of annular areas within AREA: | | | | |
| R017 | Ring 1 | not used | 1.000E+00 | --- | FRACA( 1) |
| R017 | Ring 2 | not used | 2.732E-01 | --- | FRACA( 2) |
| R017 | Ring 3 | not used | 0.000E+00 | --- | FRACA( 3) |
| R017 | Ring 4 | not used | 0.000E+00 | --- | FRACA( 4) |
| R017 | Ring 5 | not used | 0.000E+00 | --- | FRACA( 5) |
| R017 | Ring 6 | not used | 0.000E+00 | --- | FRACA( 6) |
| R017 | Ring 7 | not used | 0.000E+00 | --- | FRACA( 7) |
| R017 | Ring 8 | not used | 0.000E+00 | --- | FRACA( 8) |
| R017 | Ring 9 | not used | 0.000E+00 | --- | FRACA( 9) |
| R017 | Ring 10 | not used | 0.000E+00 | --- | FRACA(10) |
| R017 | Ring 11 | not used | 0.000E+00 | --- | FRACA(11) |
| R017 | Ring 12 | not used | 0.000E+00 | --- | FRACA(12) |
| | | | | | |
| R018 | Fruits, vegetables and grain consumption (kg/yr) | 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 |

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Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.RAD

Site-Specific Parameter Summary (continued)

| 0 Menu | Parameter | User Input | Default | Used by RESRAD (If different from user input) | Parameter Name |
|---|---|---|---|---|---|
| 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 | 0.100E+01 | FMEAT |
| R018 | Contamination fraction of milk | -1 | -1 | 0.100E+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) |
| 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) | 2.000E-05 | 2.000E-05 | --- | C12WTR |
| C14 | C-12 concentration in contaminated soil (g/g) | 3.000E-02 | 3.000E-02 | --- | C12CZ |
| C14 | Fraction of vegetation carbon from soil | 2.000E-02 | 2.000E-02 | --- | CSOIL |
| C14 | Fraction of vegetation carbon from air | 9.800E-01 | 9.800E-01 | --- | CAIR |
| C14 | C-14 evasion layer thickness in soil (m) | 3.000E-01 | 3.000E-01 | --- | DMC |
| C14 | C-14 evasion flux rate from soil (1/sec) | 7.000E-07 | 7.000E-07 | --- | EVSN |
| C14 | C-12 evasion flux rate from soil (1/sec) | 1.000E-10 | 1.000E-10 | --- | REVSN |
| C14 | Fraction of grain in beef cattle feed | 8.000E-01 | 8.000E-01 | --- | AVFG4 |
| C14 | Fraction of grain in milk cow feed | 2.000E-01 | 2.000E-01 | --- | AVFG5 |
| C14 | DCF correction factor for gaseous forms of C14 | 8.894E+01 | 8.894E+01 | --- | CO2F |
| STOR | Storage times of contaminated foodstuffs (days): | | | | |

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Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.RAD

Site-Specific Parameter Summary (continued)

| 0 Menu | Parameter | User Input | Default | Used by RESRAD (If different from user input) | Parameter Name |
|---|---|---|---|---|---|
| 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 | 17 | --- | --- | LYMAX |
| TITL | Maximum number of integration points for risk | 257 | --- | --- | KYMAX |

Summary of Pathway Selections

| Pathway | User Selection |
|---|---|
| 1 -- external gamma | active |
| 2 -- inhalation (w/o radon) | active |
| 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 | active |

```
1RESRAD, Version 6.21     T« Limit = 0.5 year        03/10/2003  11:35  Page   9
 Summary : 116-F-1 Overburden Radionuclides             File: 116-F-1_OB_rad.RAD

     Contaminated Zone Dimensions             Initial Soil Concentrations, pCi/g
     ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ             ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
       Area:  24817.00 square meters                 C-14        6.330E-01
   Thickness:     4.50 meters                        Co-60       1.620E-02
 Cover Depth:     0.00 meters                        Eu-152      5.240E-02
                                                     Eu-154      4.910E-02
0
                                             Total Dose TDOSE(t), mrem/yr
                                       Basic Radiation Dose Limit = 1.500E+01 mrem/yr
                        Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)
                        ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
    t (years):  0.000E+00  1.000E+00  3.000E+00  7.100E+00  1.500E+01  4.300E+01  1.000E+02  3.000E+02  1.000E+03
     TDOSE(t):  1.872E+00  8.728E-01  5.084E-01  3.581E-01  2.006E-01  3.316E-02  1.358E-03  3.822E-08  9.050E-17
         M(t):  1.248E-01  5.819E-02  3.389E-02  2.387E-02  1.337E-02  2.210E-03  9.055E-05  2.548E-09  6.034E-18
0Maximum TDOSE(t):  1.872E+00 mrem/yr   at t = 0.000E+00 years
```

1RESRAD, Version 6.21 T« Limit = 0.5 year 03/10/2003 11:35 Page 10
Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.RAD

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

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 2.974E-06 | 0.0000 | 1.768E-04 | 0.0001 | 0.000E+00 | 0.0000 | 6.874E-01 | 0.3672 | 3.150E-01 | 0.1683 | 2.401E-01 | 0.1282 | 4.040E-05 | 0.0000 |
| Co-60 | 1.590E-01 | 0.0850 | 1.474E-07 | 0.0000 | 0.000E+00 | 0.0000 | 1.841E-03 | 0.0010 | 1.746E-03 | 0.0009 | 4.002E-04 | 0.0002 | 2.384E-05 | 0.0000 |
| Eu-152 | 2.313E-01 | 0.1236 | 5.003E-07 | 0.0000 | 0.000E+00 | 0.0000 | 4.663E-05 | 0.0000 | 1.597E-05 | 0.0000 | 4.220E-07 | 0.0000 | 1.932E-05 | 0.0000 |
| Eu-154 | 2.347E-01 | 0.1254 | 5.987E-07 | 0.0000 | 0.000E+00 | 0.0000 | 6.354E-05 | 0.0000 | 2.176E-05 | 0.0000 | 5.751E-07 | 0.0000 | 2.633E-05 | 0.0000 |
| Total | 6.250E-01 | 0.3339 | 1.781E-04 | 0.0001 | 0.000E+00 | 0.0000 | 6.893E-01 | 0.3683 | 3.168E-01 | 0.1692 | 2.405E-01 | 0.1285 | 1.099E-04 | 0.0001 |

0

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

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 | 1.243E+00 | 0.6639 |
| Co-60 | 0.000E+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 | 1.630E-01 | 0.0871 |
| 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 | 2.314E-01 | 0.1236 |
| Eu-154 | 0.000E+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 | 2.348E-01 | 0.1254 |
| 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 | 1.872E+00 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T« Limit = 0.5 year 03/10/2003 11:35 Page 11
Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.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
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 6.801E-07 | 0.0000 | 4.044E-05 | 0.0000 | 0.000E+00 | 0.0000 | 1.594E-01 | 0.1826 | 7.649E-02 | 0.0876 | 5.735E-02 | 0.0657 | 9.239E-06 | 0.0000 |
| Co-60 | 1.394E-01 | 0.1597 | 1.292E-07 | 0.0000 | 0.000E+00 | 0.0000 | 1.613E-03 | 0.0018 | 1.531E-03 | 0.0018 | 3.508E-04 | 0.0004 | 2.090E-05 | 0.0000 |
| Eu-152 | 2.195E-01 | 0.2515 | 4.750E-07 | 0.0000 | 0.000E+00 | 0.0000 | 4.426E-05 | 0.0001 | 1.516E-05 | 0.0000 | 4.006E-07 | 0.0000 | 1.834E-05 | 0.0000 |
| Eu-154 | 2.169E-01 | 0.2485 | 5.534E-07 | 0.0000 | 0.000E+00 | 0.0000 | 5.873E-05 | 0.0001 | 2.011E-05 | 0.0000 | 5.315E-07 | 0.0000 | 2.434E-05 | 0.0000 |
| Total | 5.758E-01 | 0.6597 | 4.159E-05 | 0.0000 | 0.000E+00 | 0.0000 | 1.611E-01 | 0.1846 | 7.806E-02 | 0.0894 | 5.770E-02 | 0.0661 | 7.282E-05 | 0.0001 |

0

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

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 | 2.933E-01 | 0.3360 |
| Co-60 | 0.000E+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 | 1.429E-01 | 0.1637 |
| 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 | 2.196E-01 | 0.2516 |
| Eu-154 | 0.000E+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 | 2.170E-01 | 0.2486 |
| 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 | 8.728E-01 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T« Limit = 0.5 year 03/10/2003 11:35 Page 12
Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.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
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 3.550E-08 | 0.0000 | 2.111E-06 | 0.0000 | 0.000E+00 | 0.0000 | 8.321E-03 | 0.0164 | 3.993E-03 | 0.0079 | 2.994E-03 | 0.0059 | 4.822E-07 | 0.0000 |
| Co-60 | 1.071E-01 | 0.2107 | 9.927E-08 | 0.0000 | 0.000E+00 | 0.0000 | 1.240E-03 | 0.0024 | 1.176E-03 | 0.0023 | 2.695E-04 | 0.0005 | 1.606E-05 | 0.0000 |
| Eu-152 | 1.978E-01 | 0.3892 | 4.280E-07 | 0.0000 | 0.000E+00 | 0.0000 | 3.988E-05 | 0.0001 | 1.366E-05 | 0.0000 | 3.610E-07 | 0.0000 | 1.653E-05 | 0.0000 |
| Eu-154 | 1.852E-01 | 0.3644 | 4.726E-07 | 0.0000 | 0.000E+00 | 0.0000 | 5.016E-05 | 0.0001 | 1.718E-05 | 0.0000 | 4.540E-07 | 0.0000 | 2.079E-05 | 0.0000 |
| Total | 4.902E-01 | 0.9643 | 3.110E-06 | 0.0000 | 0.000E+00 | 0.0000 | 9.650E-03 | 0.0190 | 5.200E-03 | 0.0102 | 3.264E-03 | 0.0064 | 5.386E-05 | 0.0001 |

0

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

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 | 1.531E-02 | 0.0301 |
| Co-60 | 0.000E+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 | 1.098E-01 | 0.2160 |
| 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 | 1.979E-01 | 0.3893 |
| Eu-154 | 0.000E+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 | 1.853E-01 | 0.3646 |
| 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 | 5.084E-01 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/10/2003 11:35 Page 13
Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.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 = 7.100E+00 years
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 8.274E-11 | 0.0000 | 4.919E-09 | 0.0000 | 0.000E+00 | 0.0000 | 1.940E-05 | 0.0001 | 9.313E-06 | 0.0000 | 6.980E-06 | 0.0000 | 1.124E-09 | 0.0000 |
| Co-60 | 6.242E-02 | 0.1743 | 5.785E-08 | 0.0000 | 0.000E+00 | 0.0000 | 7.224E-04 | 0.0020 | 6.854E-04 | 0.0019 | 1.571E-04 | 0.0004 | 9.359E-06 | 0.0000 |
| Eu-152 | 1.598E-01 | 0.4463 | 3.457E-07 | 0.0000 | 0.000E+00 | 0.0000 | 3.222E-05 | 0.0001 | 1.103E-05 | 0.0000 | 2.916E-07 | 0.0000 | 1.335E-05 | 0.0000 |
| Eu-154 | 1.341E-01 | 0.3745 | 3.421E-07 | 0.0000 | 0.000E+00 | 0.0000 | 3.631E-05 | 0.0001 | 1.243E-05 | 0.0000 | 3.286E-07 | 0.0000 | 1.505E-05 | 0.0000 |
| Total | 3.563E-01 | 0.9952 | 7.506E-07 | 0.0000 | 0.000E+00 | 0.0000 | 8.104E-04 | 0.0023 | 7.182E-04 | 0.0020 | 1.647E-04 | 0.0005 | 3.776E-05 | 0.0001 |

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 7.100E+00 years
0 Water Dependent Pathways

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 | 3.570E-05 | 0.0001 |
| Co-60 | 0.000E+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 | 6.399E-02 | 0.1787 |
| 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 | 1.599E-01 | 0.4465 |
| Eu-154 | 0.000E+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 | 1.342E-01 | 0.3747 |
| 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 | 3.581E-01 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/10/2003 11:35 Page 14
Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.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 = 1.500E+01 years
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 6.790E-16 | 0.0000 | 4.037E-14 | 0.0000 | 0.000E+00 | 0.0000 | 1.592E-10 | 0.0000 | 7.649E-11 | 0.0000 | 5.732E-11 | 0.0000 | 9.223E-15 | 0.0000 |
| Co-60 | 2.205E-02 | 0.1099 | 2.043E-08 | 0.0000 | 0.000E+00 | 0.0000 | 2.552E-04 | 0.0013 | 2.421E-04 | 0.0012 | 5.548E-05 | 0.0003 | 3.306E-06 | 0.0000 |
| Eu-152 | 1.059E-01 | 0.5282 | 2.292E-07 | 0.0000 | 0.000E+00 | 0.0000 | 2.136E-05 | 0.0001 | 7.314E-06 | 0.0000 | 1.933E-07 | 0.0000 | 8.850E-06 | 0.0000 |
| Eu-154 | 7.194E-02 | 0.3587 | 1.835E-07 | 0.0000 | 0.000E+00 | 0.0000 | 1.948E-05 | 0.0001 | 6.671E-06 | 0.0000 | 1.763E-07 | 0.0000 | 8.073E-06 | 0.0000 |
| Total | 1.999E-01 | 0.9969 | 4.332E-07 | 0.0000 | 0.000E+00 | 0.0000 | 2.960E-04 | 0.0015 | 2.561E-04 | 0.0013 | 5.585E-05 | 0.0003 | 2.023E-05 | 0.0001 |

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.500E+01 years
0 Water Dependent Pathways

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 | 2.931E-10 | 0.0000 |
| Co-60 | 0.000E+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 | 2.260E-02 | 0.1127 |
| 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 | 1.060E-01 | 0.5284 |
| Eu-154 | 0.000E+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 | 7.197E-02 | 0.3589 |
| 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 | 2.006E-01 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/10/2003 11:35 Page 15
Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.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
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.074E-28 | 0.0000 | 5.175E-29 | 0.0000 | 3.874E-29 | 0.0000 | 0.000E+00 | 0.0000 |
| Co-60 | 5.516E-04 | 0.0166 | 5.112E-10 | 0.0000 | 0.000E+00 | 0.0000 | 6.384E-06 | 0.0002 | 6.057E-06 | 0.0002 | 1.388E-06 | 0.0000 | 8.270E-08 | 0.0000 |
| Eu-152 | 2.466E-02 | 0.7438 | 5.335E-08 | 0.0000 | 0.000E+00 | 0.0000 | 4.972E-06 | 0.0001 | 1.703E-06 | 0.0001 | 4.500E-08 | 0.0000 | 2.060E-06 | 0.0001 |
| Eu-154 | 7.915E-03 | 0.2387 | 2.020E-08 | 0.0000 | 0.000E+00 | 0.0000 | 2.143E-06 | 0.0001 | 7.340E-07 | 0.0000 | 1.940E-08 | 0.0000 | 8.882E-07 | 0.0000 |
| Total | 3.313E-02 | 0.9992 | 7.406E-08 | 0.0000 | 0.000E+00 | 0.0000 | 1.350E-05 | 0.0004 | 8.493E-06 | 0.0003 | 1.452E-06 | 0.0000 | 3.031E-06 | 0.0001 |

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.300E+01 years
0. Water Dependent Pathways

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 | 1.979E-28 | 0.0000 |
| Co-60 | 0.000E+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 | 5.655E-04 | 0.0171 |
| 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 | 2.467E-02 | 0.7441 |
| Eu-154 | 0.000E+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 | 7.919E-03 | 0.2388 |
| 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 | 3.316E-02 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/10/2003 11:35 Page 16
Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 |
| Co-60 | 3.026E-07 | 0.0002 | 2.804E-13 | 0.0000 | 0.000E+00 | 0.0000 | 3.502E-09 | 0.0000 | 3.322E-09 | 0.0000 | 7.613E-10 | 0.0000 | 4.536E-11 | 0.0000 |
| Eu-152 | 1.269E-03 | 0.9342 | 2.745E-09 | 0.0000 | 0.000E+00 | 0.0000 | 2.558E-07 | 0.0002 | 8.761E-08 | 0.0001 | 2.315E-09 | 0.0000 | 1.060E-07 | 0.0001 |
| Eu-154 | 8.856E-05 | 0.0652 | 2.260E-10 | 0.0000 | 0.000E+00 | 0.0000 | 2.398E-08 | 0.0000 | 8.212E-09 | 0.0000 | 2.170E-10 | 0.0000 | 9.938E-09 | 0.0000 |
| Total | 1.358E-03 | 0.9996 | 2.971E-09 | 0.0000 | 0.000E+00 | 0.0000 | 2.833E-07 | 0.0002 | 9.914E-08 | 0.0001 | 3.294E-09 | 0.0000 | 1.160E-07 | 0.0001 |

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
0 Water Dependent Pathways

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 |
| Co-60 | 0.000E+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 | 3.102E-07 | 0.0002 |
| 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 | 1.269E-03 | 0.9345 |
| Eu-154 | 0.000E+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 | 8.860E-05 | 0.0652 |
| 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 | 1.358E-03 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T« Limit = 0.5 year 03/10/2003 11:35 Page 17
Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.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
0 Water Independent Pathways (Inhalation excludes radon)

| 0 | Ground | | Inhalation | | Radon | | Plant | | Meat | | Milk | | Soil | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 |
| Co-60 | 1.095E-18 | 0.0000 | 1.015E-24 | 0.0000 | 0.000E+00 | 0.0000 | 1.267E-20 | 0.0000 | 1.203E-20 | 0.0000 | 2.755E-21 | 0.0000 | 1.642E-22 | 0.0000 |
| Eu-152 | 3.820E-08 | 0.9993 | 8.265E-14 | 0.0000 | 0.000E+00 | 0.0000 | 7.701E-12 | 0.0002 | 2.637E-12 | 0.0001 | 6.970E-14 | 0.0000 | 3.191E-12 | 0.0001 |
| Eu-154 | 1.261E-11 | 0.0003 | 3.218E-17 | 0.0000 | 0.000E+00 | 0.0000 | 3.415E-15 | 0.0000 | 1.170E-15 | 0.0000 | 3.091E-17 | 0.0000 | 1.415E-15 | 0.0000 |
| Total | 3.821E-08 | 0.9996 | 8.269E-14 | 0.0000 | 0.000E+00 | 0.0000 | 7.704E-12 | 0.0002 | 2.638E-12 | 0.0001 | 6.973E-14 | 0.0000 | 3.193E-12 | 0.0001 |

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years
0, Water Dependent Pathways

| 0 | Water | | Fish | | Radon | | Plant | | Meat | | Milk | | All Pathways* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radio- | | | | | | | | | | | | | | |
| Nuclide | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. | mrem/yr | fract. |
| C-14 | 0.000E+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 |
| Co-60 | 0.000E+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 | 1.123E-18 | 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 | 3.821E-08 | 0.9997 |
| Eu-154 | 0.000E+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 | 1.262E-11 | 0.0003 |
| 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 | 3.822E-08 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/10/2003 11:35 Page 18
Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.RAD

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

0

| 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. |
| C-14 | 0.000E+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 |
| Co-60 | 0.000E+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 | 5.717E-24 | 0.0000 | 1.918E-17 | 0.2119 | 0.000E+00 | 0.0000 | 4.039E-17 | 0.4463 | 1.383E-17 | 0.1528 | 3.655E-19 | 0.0040 | 1.674E-17 | 0.1849 |
| Eu-154 | 0.000E+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 | 5.717E-24 | 0.0000 | 1.918E-17 | 0.2119 | 0.000E+00 | 0.0000 | 4.039E-17 | 0.4463 | 1.383E-17 | 0.1528 | 3.655E-19 | 0.0040 | 1.674E-17 | 0.1849 |

0

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

0

| 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. |
| C-14 | 0.000E+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 |
| Co-60 | 0.000E+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 | 9.050E-17 | 1.0000 |
| Eu-154 | 0.000E+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 | 9.050E-17 | 1.0000 |

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.21 T« Limit = 0.5 year 03/10/2003 11:35 Page 19
Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.RAD

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

| 0Parent (i) | Product (j) | Branch Fraction* | DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00 | 1.000E+00 | 3.000E+00 | 7.100E+00 | 1.500E+01 | 4.300E+01 | 1.000E+02 | 3.000E+02 | 1.000E+03 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C-14 | C-14 | 1.000E+00 | 1.963E+00 | 4.634E-01 | 2.419E-02 | 5.639E-05 | 4.630E-10 | 3.127E-28 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 0Co-60 | Co-60 | 1.000E+00 | 1.006E+01 | 8.822E+00 | 6.779E+00 | 3.950E+00 | 1.395E+00 | 3.491E-02 | 1.915E-05 | 6.930E-17 | 0.000E+00 |
| 0Eu-152 | Eu-152 | 7.208E-01 | 3.183E+00 | 3.021E+00 | 2.722E+00 | 2.199E+00 | 1.458E+00 | 3.394E-01 | 1.746E-02 | 5.256E-07 | 7.867E-23 |
| 0Eu-152 | Eu-152 | 2.792E-01 | 1.233E+00 | 1.170E+00 | 1.055E+00 | 8.519E-01 | 5.646E-01 | 1.315E-01 | 6.764E-03 | 2.036E-07 | 3.047E-23 |
| Eu-152 | Gd-152 | 2.792E-01 | 4.477E-17 | 1.313E-16 | 2.913E-16 | 5.717E-16 | 9.689E-16 | 1.568E-15 | 1.739E-15 | 1.744E-15 | 1.727E-15 |
| Eu-152 | ÅDSR(j) | | 1.233E+00 | 1.170E+00 | 1.055E+00 | 8.519E-01 | 5.646E-01 | 1.315E-01 | 6.764E-03 | 2.036E-07 | 1.727E-15 |
| 0Eu-154 | Eu-154 | 1.000E+00 | 4.782E+00 | 4.419E+00 | 3.775E+00 | 2.732E+00 | 1.466E+00 | 1.613E-01 | 1.805E-03 | 2.570E-10 | 2.802E-34 |

*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life ó 0.5 yr) daughters.

0

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 1.500E+01 mrem/yr

| 0Nuclide (i) | t= 0.000E+00 | 1.000E+00 | 3.000E+00 | 7.100E+00 | 1.500E+01 | 4.300E+01 | 1.000E+02 | 3.000E+02 | 1.000E+03 |
|---|---|---|---|---|---|---|---|---|---|
| C-14 | 7.641E+00 | 3.237E+01 | 6.202E+02 | 2.660E+05 | 3.240E+10 | *4.454E+12 | *4.454E+12 | *4.454E+12 | *4.454E+12 |
| Co-60 | 1.490E+00 | 1.700E+00 | 2.213E+00 | 3.797E+00 | 1.075E+01 | 4.297E+02 | 7.834E+05 | *1.131E+15 | *1.131E+15 |
| Eu-152 | 3.397E+00 | 3.579E+00 | 3.971E+00 | 4.916E+00 | 7.417E+00 | 3.186E+01 | 6.192E+02 | 2.057E+07 | *1.765E+14 |
| Eu-154 | 3.137E+00 | 3.394E+00 | 3.974E+00 | 5.490E+00 | 1.023E+01 | 9.300E+01 | 8.312E+03 | 5.836E+10 | *2.639E+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 = 0.000E+00 years

| 0Nuclide (i) | Initial (pCi/g) | tmin (years) | DSR(i,tmin) | G(i,tmin) (pCi/g) | DSR(i,tmax) | G(i,tmax) (pCi/g) |
|---|---|---|---|---|---|---|
| C-14 | 6.330E-01 | 0.000E+00 | 1.963E+00 | 7.641E+00 | 1.963E+00 | 7.641E+00 |
| Co-60 | 1.620E-02 | 0.000E+00 | 1.006E+01 | 1.490E+00 | 1.006E+01 | 1.490E+00 |
| Eu-152 | 5.240E-02 | 0.000E+00 | 4.415E+00 | 3.397E+00 | 4.415E+00 | 3.397E+00 |
| Eu-154 | 4.910E-02 | 0.000E+00 | 4.782E+00 | 3.137E+00 | 4.782E+00 | 3.137E+00 |

1RESRAD, Version 6.21 T< Limit = 0.5 year 03/10/2003 11:35 Page 20
Summary : 116-F-1 Overburden Radionuclides File: 116-F-1_OB_rad.RAD

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

| 0Nuclide (j) | Parent (i) | BRF(i) | DOSE(j,t), mrem/yr t= 0.000E+00 | 1.000E+00 | 3.000E+00 | 7.100E+00 | 1.500E+01 | 4.300E+01 | 1.000E+02 | 3.000E+02 | 1.000E+03 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ |
| C-14 | C-14 | 1.000E+00 | 1.243E+00 | 2.933E-01 | 1.531E-02 | 3.570E-05 | 2.931E-10 | 1.979E-28 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 0Co-60 | Co-60 | 1.000E+00 | 1.630E-01 | 1.429E-01 | 1.098E-01 | 6.399E-02 | 2.260E-02 | 5.655E-04 | 3.102E-07 | 1.123E-18 | 0.000E+00 |
| 0Eu-152 | Eu-152 | 7.208E-01 | 1.668E-01 | 1.583E-01 | 1.427E-01 | 1.152E-01 | 7.638E-02 | 1.778E-02 | 9.150E-04 | 2.754E-08 | 4.122E-24 |
| Eu-152 | Eu-152 | 2.792E-01 | 6.460E-02 | 6.132E-02 | 5.526E-02 | 4.464E-02 | 2.959E-02 | 6.888E-03 | 3.544E-04 | 1.067E-08 | 1.597E-24 |
| Eu-152 | ÄDOSE(j) | | 2.314E-01 | 2.196E-01 | 1.979E-01 | 1.599E-01 | 1.060E-01 | 2.467E-02 | 1.269E-03 | 3.821E-08 | 5.719E-24 |
| 0Gd-152 | Eu-152 | 2.792E-01 | 2.346E-18 | 6.878E-18 | 1.527E-17 | 2.995E-17 | 5.077E-17 | 8.214E-17 | 9.112E-17 | 9.136E-17 | 9.050E-17 |
| 0Eu-154 | Eu-154 | 1.000E+00 | 2.348E-01 | 2.170E-01 | 1.853E-01 | 1.342E-01 | 7.197E-02 | 7.919E-03 | 8.860E-05 | 1.262E-11 | 0.000E+00 |
| ffffffff | ffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff |

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

| 0Nuclide (j) | Parent (i) | BRF(i) | S(j,t), pCi/g t= 0.000E+00 | 1.000E+00 | 3.000E+00 | 7.100E+00 | 1.500E+01 | 4.300E+01 | 1.000E+02 | 3.000E+02 | 1.000E+03 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ | ÄÄÄÄÄÄÄÄÄ |
| C-14 | C-14 | 1.000E+00 | 6.330E-01 | 1.448E-01 | 7.561E-03 | 1.764E-05 | 1.451E-10 | 9.852E-29 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 0Co-60 | Co-60 | 1.000E+00 | 1.620E-02 | 1.420E-02 | 1.091E-02 | 6.358E-03 | 2.246E-03 | 5.619E-05 | 3.082E-08 | 1.116E-19 | 0.000E+00 |
| 0Eu-152 | Eu-152 | 7.208E-01 | 3.777E-02 | 3.585E-02 | 3.231E-02 | 2.610E-02 | 1.730E-02 | 4.028E-03 | 2.072E-04 | 6.238E-09 | 9.336E-25 |
| Eu-152 | Eu-152 | 2.792E-01 | 1.463E-02 | 1.389E-02 | 1.251E-02 | 1.011E-02 | 6.701E-03 | 1.560E-03 | 8.027E-05 | 2.416E-09 | 3.616E-25 |
| Eu-152 | ÄS(j): | | 5.240E-02 | 4.974E-02 | 4.482E-02 | 3.621E-02 | 2.400E-02 | 5.588E-03 | 2.875E-04 | 8.654E-09 | 1.295E-24 |
| 0Gd-152 | Eu-152 | 2.792E-01 | 0.000E+00 | 9.149E-17 | 2.608E-16 | 5.573E-16 | 9.775E-16 | 1.611E-15 | 1.792E-15 | 1.797E-15 | 1.780E-15 |
| 0Eu-154 | Eu-154 | 1.000E+00 | 4.910E-02 | 4.538E-02 | 3.876E-02 | 2.806E-02 | 1.505E-02 | 1.656E-03 | 1.853E-05 | 2.639E-12 | 2.878E-36 |
| ffffffff | ffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff | ffffffffff |

BRF(i) is the branch fraction of the parent nuclide.
0RESCALC.EXE execution time = 5.18 seconds

# CALCULATION BRIEF EXCERPTS

## DISCLAIMER FOR CALCULATIONS

The calculations that are provided in the following appendix are included for reference only. Use of these calculations by persons who do not have access to all of their pertinent factors could lead to incorrect conclusions or assumptions.

Before applying these calculations to work activities or projects outside the context of this report, these calculations must be thoroughly reviewed with appropriate and authorized Hanford Site ERC personnel. Without this review, the ER Project cannot assume any responsibility for the use of these calculations.

## CALCULATION BRIEFS

The following calculation briefs have been prepared in accordance with BHI-DE-01, *Design Engineering Procedures Manual*, EDPI-4.37-01, "Project Calculations," Bechtel Hanford, Inc., Richland, Washington.

*116-F-1 Lewis Canal Trench Sample Variance*, Calculation No. 0100F-CA-V0150, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

*Lewis Canal Trench/Overburden Sampling Design*, Calculation No. 0100F-CA-V0154, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

*116-F-1 Lewis Canal Cleanup Verification 95% UCL Calculation*, Calculation No. 0100F-CA-V0138, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

*116-F-1 Lewis Canal RESRAD Calculation*, Calculation No. 0100F-CA-V0140, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

*116-F-1 Lewis Canal Comparison to Drinking Water Standards (MCL)*, Calculation No. 0100F-CA-V0139, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

NOTE: The calculation briefs referenced in this appendix are kept in the active Environmental Restoration Contractor 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:** | Group 4 Remedial Action | **Job No.** | 22192 |
| **Area** | 100-F Area | | |
| **Discipline** | Enviromental | **Calc. No.** | 0100F-CA-V0150 |
| **Subject** | 116-F-1 Lewis Canal Trench Sample Variance | | |
| **Computer Program** | Excel | **Program No.** | Excel 97 |

Use of this calculation by persons who do not have access to all of the pertinent facts could lead to incorrect conclusions or assumptions. Before applying this calculation in your work, this calculation must be thoroughly reviewed with appropriate and authorized Hanford site ERC personnel. Without this review, the ERC cannot assume any responsibility for the use of these calculations.

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

| Rev. | Sheet Numbers | Originator | Checker | Reviewer | Approval | Date |
|---|---|---|---|---|---|---|
| 0 | Cover - 1<br>Calc Summary - 1<br>Shallow Zone Calculations - 3<br>Overburden Zone Calculations - 2<br>Shallow Zone Data- 4<br>Overburden Zone Data 1<br>Total - 12 | 3/18/2003<br>MT Stankovich | SW Calison<br>3-18-03<br>SW Calison | JE Thomson<br>3/18/03<br>JE Thomson | 3/19/03<br>MA Buckmaster | 3/19/03 |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**SUMMARY OF REVISIONS**

*Obtain Calc. No. from DIS

DE01-437.03

January-2003

**CALCULATION SHEET**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Bechtel Hanford Inc. | | | | | | | |
| Originator | M. T. Stankovich | Date | 3/18/2003 | Calc. No. | 0100F-CA-V0150 | Rev. No. | 0 |
| Project | Group 4 Remedial Action | Job No. | 22192 | Checked | SW Callison | Date | 3-18-03 |
| Subject | 116-F-1 Lewis Canal Trench Sample Variance | | | | | Sheet No. | 1 of 11 |

**Conclusion:**

The required number of samples calculated (1 samples) for each decision sub-unit is less than the default number (4 samples) specified in the "100 Area Remedial Action Sampling and Analysis Plan" DOE/RL-96-22, Rev 3. Therefore, the default number of samples will be collected from each shallow zone and overburden zone decision sub-unit.

**Problem:**

Calculate the number of verification samples required for 116-F-1 Shallow and Overburden Zone Decision Unit verification sampling as required in "100 Area Remedial Action Sampling and Analysis Plan" (DOE/RL-96-22, Rev 3) and "Instruction Guide for the Remediation of 100 Areas Waste Sites" (0100X-IG-G0001, Rev 4).

**Given:**

1) Sample locations for the 116-F-1 Lewis Canal Trench Shallow and Overburden Zone are identified on the 116-F-1 Lewis Canal Shallow and Overburden Zone Design, Calculation numbers 0100F-CA-V0154.
2) Lookup values from DOE/RL-96-22, Rev 3.
3) Sample Design requirements from DOE/RL-96-22, Rev 3 and 0100X-IG-G0001, Rev 4.

**Solution:**

Calculation methodology is described in Appendix A of DOE/RL-96-22, Rev 3. Data from attached worksheets are used to calculate the required number of verification samples. Variance calculation is based on the same three isotopes used to develop the statistical approach in DOE/RL-96-22, Rev 3. 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 |
| 2-4 | Shallow Zone | Samples Calculation |
| 5-6 | Overburden Zone | Samples Calculation |
| 7-10 | Shallow Zone Data | Sample Management Shallow Zone Raw Data |
| 11 | Overburden Zone Data | Sample Management Overburden Zone Raw Data |

## CALCULATION SHEET

Bechtel Hanford Inc.

Originator M. T. Stankovich Date 3/18/2003 Calc. No. 0100F-CA-V0150 Rev. No. 0
Project Group 4 Remedial Action Job No. 22192 Checked SW Callison SWC Date 3-18-03
Subject 116-F-1 Lewis Canal Trench Sample Variance Sheet No. 2 of 11

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-V0156.
Mean, Standard Deviation, *t*, and Number of Samples formulas are from DOE/RL-96-22, Appendix A.

Decision Unit: Shallow Zone
Samples values from GEA analysis
Sample Areas A, B, C, D, E, F, & G

| Sample # | Sample Date | Location | Cobalt-60 pCi/g | Q | Cesium-137 pCi/g | Q | Europium-152 pCi/g | Q |
|---|---|---|---|---|---|---|---|---|
| Look-up Value (HT) ==========> | | | 1.4 | | 6.2 | | 3.3 | |
| J008Y6 | 10-Dec-02 | SA1-2 | 0.045 | U | 0.228 | | 0.095 | U |
| J008Y7 | 10-Dec-02 | SA1-3 | 0.095 | U | 0.088 | U | 0.149 | U |
| J008Y8 | 10-Dec-02 | SA1-4 | 0.063 | U | 0.195 | | 0.18 | U |
| J008Y9 | 10-Dec-02 | SA1-10 | 0.051 | U | 0.138 | | 0.1 | U |
| J00900 | 10-Dec-02 | SA1-14 | 0.035 | U | 0.048 | | 0.088 | U |
| J00901 | 10-Dec-02 | SA1-16 | 0.048 | U | 0.095 | | 0.12 | U |
| J00902 | 10-Dec-02 | SA2-3 | 0.057 | U | 0.222 | | 0.13 | U |
| J00903 | 10-Dec-02 | SA2-6 | 0.082 | U | 0.117 | | 0.18 | U |
| J00904 | 10-Dec-02 | SA2-7 | 0.086 | U | 0.189 | | 0.19 | U |
| J00905 | 10-Dec-02 | SA2-10 | 0.046 | U | 0.13 | | 0.13 | U |
| J00906 | 10-Dec-02 | SA2-14 | 0.048 | U | 0.067 | U | 0.13 | U |
| J00907 | 10-Dec-02 | SA2-15 | 0.081 | U | 0.124 | | 0.15 | U |
| J00908 | 10-Dec-02 | SA3-1 | 0.065 | U | 0.061 | U | 0.14 | U |
| J00909 | 10-Dec-02 | SA3-2 | 0.058 | U | 0.052 | U | 0.13 | U |
| J00910 | 10-Dec-02 | SA3-4 | 0.084 | U | 0.081 | U | 0.18 | U |
| J00911 | 10-Dec-02 | SA3-5 | 0.067 | U | 0.067 | U | 0.15 | U |
| J00912 | 10-Dec-02 | SA3-9 | 0.059 | U | 0.056 | U | 0.13 | U |
| J00913 | 10-Dec-02 | SA3-11 | 0.07 | U | 0.073 | U | 0.2 | U |
| J00914 | 10-Dec-02 | SA4-3 | 0.05 | U | 0.045 | U | 0.1 | U |
| J00915 | 10-Dec-02 | SA4-4 | 0.056 | U | 0.051 | U | 0.11 | U |
| J00916 | 10-Dec-02 | SA4-7 | 0.039 | U | 0.041 | U | 0.094 | U |
| J00917 | 10-Dec-02 | SA4-9 | 0.043 | U | 0.036 | U | 0.083 | U |
| J00918 | 10-Dec-02 | SA4-12 | 0.063 | U | 0.05 | U | 0.15 | U |
| J00919 | 10-Dec-02 | SA4-13 | 0.038 | U | 0.034 | U | 0.085 | U |
| J00920 | 10-Dec-02 | SB5-1 | 0.061 | U | 0.049 | U | 0.12 | U |
| J00921 | 10-Dec-02 | SB5-2 | 0.061 | U | 0.058 | U | 0.13 | U |
| J00922 | 10-Dec-02 | SB5-5 | 0.047 | U | 0.043 | U | 0.11 | U |
| J00923 | 10-Dec-02 | SB5-7 | 0.053 | U | 0.049 | U | 0.12 | U |
| J00924 | 10-Dec-02 | SB5-13 | 0.063 | U | 0.077 | U | 0.17 | U |
| J00925 | 10-Dec-02 | SB5-15 | 0.064 | U | 0.053 | U | 0.12 | U |
| J00926 | 10-Dec-02 | SB6-1 | 0.231 | | 1.28 | | 2.42 | |
| J00927 | 10-Dec-02 | SB6-10 | 0.054 | U | 0.048 | U | 0.12 | U |
| J00928 | 10-Dec-02 | SB6-12 | 0.062 | U | 0.092 | U | 0.2 | U |
| J00929 | 10-Dec-02 | SB6-13 | 0.049 | U | 0.041 | U | 0.11 | U |
| J00930 | 10-Dec-02 | SB6-15 | 0.068 | U | 0.064 | U | 0.14 | U |
| J00931 | 10-Dec-02 | SB6-16 | 0.05 | U | 0.043 | U | 0.12 | U |
| J00932 | 10-Dec-02 | SB7-1 | 0.053 | U | 0.05 | U | 0.12 | U |
| J00933 | 10-Dec-02 | SB7-3 | 0.058 | U | 0.053 | U | 0.13 | U |
| J00934 | 10-Dec-02 | SB7-4 | 0.075 | U | 0.053 | U | 0.15 | U |
| J00935 | 10-Dec-02 | SB7-5 | 0.071 | U | 0.073 | | 0.26 | |
| J00936 | 10-Dec-02 | SB7-8 | 0.053 | U | 0.052 | U | 0.13 | U |
| J00937 | 10-Dec-02 | SB7-11 | 0.044 | U | 0.052 | U | 0.12 | U |
| J00938 | 10-Dec-02 | SB8-2 | 0.043 | U | 0.036 | U | 0.087 | U |
| J00939 | 10-Dec-02 | SB8-3 | 0.036 | U | 0.036 | U | 0.084 | U |
| J00940 | 10-Dec-02 | SB8-4 | 0.042 | U | 0.045 | U | 0.11 | U |
| J00941 | 10-Dec-02 | SB8-8 | 0.041 | U | 0.058 | U | 0.092 | U |
| J00942 | 10-Dec-02 | SB8-12 | 0.029 | U | 0.033 | U | 0.078 | U |
| J00943 | 10-Dec-02 | SB8-13 | 0.034 | U | 0.033 | U | 0.081 | U |
| J00944 | 09-Dec-02 | SC9-3 | 0.13 | U | 0.13 | | 0.406 | |

Shallow Zone

**CALCULATION SHEET**

Bechtel Hanford Inc.

Originator M. T. Stankovich Date 3/18/2003 Calc. No. 0100F-CA-V0150 Rev. No. 0

Project Group 4 Remedial Action Job No. 22192 Checked SW Callison Date 3-18-03

Subject 116-F-1 Lewis Canal Trench Sample Variance Sheet No. 3 of 11

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 188 | J00945 | 09-Dec-02 | SC9-4 | 0.055 | U | 0.048 | | 0.105 | |
| 189 | J00946 | 09-Dec-02 | SC9-5 | 0.082 | U | 0.062 | U | 0.16 | U |
| 190 | J00947 | 09-Dec-02 | SC9-10 | 0.052 | U | 0.044 | U | 0.11 | U |
| 191 | J00948 | 09-Dec-02 | SC9-14 | 0.1 | | 0.83 | | 1.48 | |
| 192 | J00949 | 09-Dec-02 | SC9-16 | 0.11 | U | 0.181 | | 0.29 | U |
| 193 | J00950 | 09-Dec-02 | SC10-3 | 0.052 | U | 0.045 | U | 0.11 | U |
| 194 | J00951 | 09-Dec-02 | SC10-4 | 0.074 | U | 0.059 | U | 0.14 | U |
| 195 | J00952 | 09-Dec-02 | SC10-8 | 0.12 | U | 0.384 | | 0.744 | |
| 196 | J00953 | 09-Dec-02 | SC10-10 | 0.061 | U | 0.078 | U | 0.481 | |
| 197 | J00954 | 09-Dec-02 | SC10-14 | 0.05 | U | 0.051 | U | 0.11 | U |
| 198 | J00955 | 09-Dec-02 | SC10-16 | 0.067 | U | 0.167 | | 0.442 | |
| 199 | J00956 | 09-Dec-02 | SC1-2 | 0.13 | U | 0.444 | | 0.756 | |
| 200 | J00957 | 09-Dec-02 | SC1-3 | 0.044 | U | 0.047 | U | 0.12 | U |
| | J00958 | 09-Dec-02 | SC1-4 | 0.17 | U | 0.74 | | 1.26 | |
| | J00959 | 09-Dec-02 | SC1-10 | 0.1 | U | 0.608 | | 1.34 | |
| | J00960 | 09-Dec-02 | SC1-13 | 0.06 | U | 0.087 | | 0.081 | U |
| | J00961 | 09-Dec-02 | SC1-16 | 0.058 | U | 0.065 | U | 0.15 | U |
| | J00962 | 09-Dec-02 | SC2-3 | 0.074 | U | 0.323 | | 0.673 | |
| | J00963 | 09-Dec-02 | SC2-6 | 0.085 | U | 0.384 | | 0.733 | |
| | J00964 | 09-Dec-02 | SC2-7 | 0.076 | U | 0.082 | | 0.165 | |
| | J00965 | 09-Dec-02 | SC2-10 | 0.059 | U | 0.057 | U | 0.13 | U |
| | J00966 | 09-Dec-02 | SC2-14 | 0.13 | U | 0.441 | | 1.35 | |
| | J00967 | 09-Dec-02 | SC2-15 | 0.069 | U | 0.242 | | 0.482 | |
| | J00968 | 19-Nov-02 | SD3-1 | 0.091 | U | 0.083 | U | 0.2 | U |
| | J00969 | 19-Nov-02 | SD3-2 | 0.062 | U | 0.062 | U | 0.15 | U |
| | J00970 | 19-Nov-02 | SD3-4 | 0.1 | U | 0.085 | U | 0.23 | U |
| | J00971 | 19-Nov-02 | SD3-5 | 0.067 | U | 0.07 | U | 0.14 | U |
| | J00972 | 19-Nov-02 | SD3-9 | 0.067 | U | 0.064 | U | 0.14 | U |
| | J00973 | 19-Nov-02 | SD3-11 | 0.12 | U | 0.13 | U | 0.25 | U |
| | J00974 | 19-Nov-02 | SD4-3 | 0.081 | U | 0.082 | U | 0.19 | U |
| | J00975 | 19-Nov-02 | SD4-4 | 0.11 | U | 0.07 | U | 0.2 | U |
| | J00976 | 19-Nov-02 | SD4-7 | 0.078 | U | 0.077 | U | 0.17 | U |
| | J00977 | 19-Nov-02 | SD4-9 | 0.077 | U | 0.057 | U | 0.14 | U |
| | J00978 | 19-Nov-02 | SD4-12 | 0.12 | U | 0.11 | U | 0.21 | U |
| | J00979 | 19-Nov-02 | SD4-13 | 0.054 | U | 0.063 | U | 0.15 | U |
| | J00980 | 19-Nov-02 | SD5-1 | 0.11 | U | 0.087 | U | 0.26 | U |
| | J00981 | 19-Nov-02 | SD5-2 | 0.052 | U | 0.052 | U | 0.12 | U |
| | J00982 | 19-Nov-02 | SD5-5 | 0.067 | U | 0.068 | U | 0.14 | U |
| | J00983 | 19-Nov-02 | SD5-7 | 0.087 | U | 0.077 | U | 0.15 | U |
| | J00984 | 19-Nov-02 | SD5-13 | 0.099 | U | 0.071 | U | 0.19 | U |
| | J00985 | 19-Nov-02 | SD5-15 | 0.083 | U | 0.171 | | 0.429 | |
| | J00986 | 19-Nov-02 | SD6-1 | 0.053 | U | 0.054 | U | 0.13 | U |
| | J00987 | 19-Nov-02 | SD6-10 | 0.051 | U | 0.048 | U | 0.11 | U |
| | J00988 | 19-Nov-02 | SD6-12 | 0.073 | U | 0.062 | U | 0.14 | U |
| | J00989 | 19-Nov-02 | SD6-13 | 0.047 | U | 0.227 | | 0.458 | |
| | J00990 | 19-Nov-02 | SD6-15 | 0.084 | U | 0.063 | U | 0.17 | U |
| | J00991 | 19-Nov-02 | SD6-16 | 0.041 | U | 0.044 | U | 0.1 | U |
| | J00992 | 19-Nov-02 | SE7-1 | 0.069 | U | 0.056 | U | 0.12 | U |
| | J00993 | 19-Nov-02 | SE7-3 | 0.036 | U | 0.036 | U | 0.088 | U |
| | J00994 | 19-Nov-02 | SE7-4 | 0.054 | U | 0.06 | U | 0.14 | U |
| | J00995 | 19-Nov-02 | SE7-5 | 0.041 | U | 0.037 | U | 0.089 | U |
| | J00996 | 19-Nov-02 | SE7-8 | 0.057 | U | 0.049 | U | 0.11 | U |
| | J00997 | 19-Nov-02 | SE7-11 | 0.13 | U | 0.11 | U | 0.22 | U |
| | J00998 | 19-Nov-02 | SE8-2 | 0.055 | U | 0.043 | U | 0.14 | U |
| | J00999 | 19-Nov-02 | SE8-3 | 0.089 | U | 0.07 | U | 0.18 | U |
| | J009B0 | 19-Nov-02 | SE8-4 | 0.096 | U | 0.729 | | 0.979 | |
| | J009B1 | 19-Nov-02 | SE8-8 | 0.096 | U | 0.084 | U | 0.18 | U |
| | J009B2 | 19-Nov-02 | SE8-12 | 0.062 | U | 0.048 | U | 0.12 | U |
| | J009B3 | 19-Nov-02 | SE8-13 | 0.039 | U | 0.037 | U | 0.09 | U |
| | J009B4 | 19-Nov-02 | SE9-3 | 0.074 | U | 0.055 | U | 0.15 | U |
| | J009B5 | 19-Nov-02 | SE9-4 | 0.062 | U | 0.396 | | 0.858 | |
| | J009B6 | 19-Nov-02 | SE9-5 | 0.043 | U | 0.04 | U | 0.1 | U |
| | J009B7 | 19-Nov-02 | SE9-10 | 0.068 | U | 0.052 | U | 0.13 | U |

Shallow Zone

**CALCULATION SHEET**

Bechtel Hanford Inc.

Originator M. T. Stankovich Date 3/18/2003 Calc. No. 0100F-CA-V0150 Rev. No. 0

Project Group 4 Remedial Action Job No. 22192 Checked SW Callison SWC Date 3-18-03

Subject 116-F-1 Lewis Canal Trench Sample Variance Sheet No. 4 of 11

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| J009B8 | 19-Nov-02 | SE9-14 | 0.038 | U | 0.035 | U | 0.094 | U |
| J009B9 | 19-Nov-02 | SE9-16 | 0.059 | U | 0.053 | U | 0.13 | U |
| J009C0 | 19-Nov-02 | SE10-3 | 0.04 | U | 0.037 | U | 0.093 | U |
| J009C1 | 19-Nov-02 | SE10-4 | 0.048 | U | 0.045 | U | 0.1 | U |
| J009C2 | 19-Nov-02 | SE10-8 | 0.078 | U | 0.064 | U | 0.13 | U |
| J009C3 | 19-Nov-02 | SE10-10 | 0.043 | U | 0.044 | U | 0.11 | U |
| J009C4 | 19-Nov-02 | SE10-14 | 0.11 | U | 0.083 | U | 0.22 | U |
| J009C5 | 19-Nov-02 | SE10-16 | 0.057 | U | 0.055 | U | 0.13 | U |
| J009C6 | 18-Nov-02 | SF1-2 | 0.14 | U | 0.248 | | 0.363 | |
| J009C7 | 18-Nov-02 | SF1-3 | 0.061 | U | 0.063 | U | 0.15 | U |
| J009C8 | 18-Nov-02 | SF1-4 | 0.13 | U | 0.11 | U | 0.27 | U |
| J009C9 | 18-Nov-02 | SF1-10 | 0.054 | U | 0.062 | U | 0.14 | U |
| J009D0 | 18-Nov-02 | SF1-13 | 0.1 | U | 0.074 | U | 0.17 | U |
| J009D1 | 18-Nov-02 | SF1-16 | 0.098 | U | 0.086 | U | 0.19 | U |
| J009D2 | 18-Nov-02 | SF2-3 | 0.04 | U | 0.067 | U | 0.1 | U |
| J009D3 | 18-Nov-02 | SF2-6 | 0.074 | U | 0.068 | U | 0.16 | U |
| J009D4 | 18-Nov-02 | SF2-7 | 0.037 | U | 0.036 | U | 0.081 | U |
| J009D5 | 18-Nov-02 | SF2-10 | 0.064 | U | 0.055 | U | 0.16 | U |
| J009D6 | 18-Nov-02 | SF2-14 | 0.077 | U | 0.085 | U | 0.17 | U |
| J009D7 | 18-Nov-02 | SF2-15 | 0.051 | U | 0.092 | U | 0.093 | |
| J009D8 | 18-Nov-02 | SF3-1 | 0.089 | U | 0.066 | U | 0.19 | U |
| J009D9 | 18-Nov-02 | SF3-2 | 0.07 | U | 0.067 | U | 0.15 | U |
| J009F0 | 18-Nov-02 | SF3-4 | 0.079 | U | 0.081 | U | 0.2 | U |
| J009F1 | 18-Nov-02 | SF3-5 | 0.081 | U | 0.087 | U | 0.16 | U |
| J009F2 | 18-Nov-02 | SF3-9 | 0.051 | U | 0.045 | U | 0.11 | U |
| J009F3 | 18-Nov-02 | SF3-11 | 0.12 | U | 0.224 | | 0.688 | |
| J009F4 | 18-Nov-02 | SF4-3 | 0.065 | U | 0.064 | U | 0.15 | U |
| J009F5 | 18-Nov-02 | SF4-4 | 0.082 | U | 0.06 | U | 0.16 | U |
| J009F6 | 18-Nov-02 | SF4-7 | 0.049 | U | 0.044 | U | 0.098 | U |
| J009F7 | 18-Nov-02 | SF4-8 | 0.034 | U | 0.028 | U | 0.078 | U |
| J009F8 | 18-Nov-02 | SF4-12 | 0.059 | U | 0.052 | U | 0.13 | U |
| J009F9 | 18-Nov-02 | SF4-13 | 0.228 | | 0.705 | | 2.77 | |
| J009H0 | 18-Nov-02 | SG5-1 | 0.071 | U | 0.061 | U | 0.14 | U |
| J009H1 | 18-Nov-02 | SG5-2 | 0.033 | U | 0.036 | U | 0.088 | U |
| J009H2 | 18-Nov-02 | SG5-5 | 0.066 | U | 0.047 | U | 0.14 | U |
| J009H3 | 18-Nov-02 | SG5-7 | 0.043 | U | 0.04 | U | 0.095 | U |
| J009H4 | 18-Nov-02 | SG5-13 | 0.043 | U | 0.04 | U | 0.094 | U |
| J009H5 | 18-Nov-02 | SG5-15 | 0.1 | U | 0.073 | U | 0.17 | U |
| J009H6 | 18-Nov-02 | SG6-1 | 0.051 | U | 0.044 | U | 0.11 | U |
| J009H7 | 18-Nov-02 | SG6-10 | 0.089 | U | 0.057 | U | 0.206 | |
| J009H8 | 10-Dec-02 | SG6-12 | 0.073 | U | 0.072 | U | 0.14 | U |
| J009H9 | 18-Nov-02 | SG6-13 | 0.05 | U | 0.042 | U | 0.1 | U |
| J009J0 | 10-Dec-02 | SG6-15 | 0.065 | U | 0.082 | | 0.16 | U |
| J009J1 | 10-Dec-02 | SG6-16 | 0.058 | U | 0.057 | | 0.12 | U |
| J009J2 | 18-Nov-02 | SG7-1 | 0.065 | U | 0.057 | U | 0.14 | U |
| J009J3 | 18-Nov-02 | SG7-3 | 0.069 | U | 0.07 | U | 0.13 | U |
| J009J4 | 18-Nov-02 | S-G7-4 | 0.046 | U | 0.045 | U | 0.11 | U |
| J009J5 | 18-Nov-02 | S-G7-5 | 0.071 | U | 0.073 | U | 0.16 | U |
| J009J6 | 18-Nov-02 | S-G7-8 | 0.049 | U | 0.052 | U | 0.11 | U |
| J009J7 | 18-Nov-02 | S-G7-11 | 0.061 | U | 0.049 | U | 0.13 | U |
| J009J8 | 18-Nov-02 | S-G8-2 | 0.064 | U | 0.044 | U | 0.11 | U |
| J009J9 | 18-Nov-02 | SG8-3 | 0.038 | U | 0.047 | U | 0.173 | |
| J009K0 | 18-Nov-02 | SG8-4 | 0.065 | U | 0.062 | U | 0.15 | U |
| J009K1 | 18-Nov-02 | SG8-8 | 0.043 | U | 0.037 | U | 0.087 | U |
| J009K2 | 18-Nov-02 | SG8-12 | 0.047 | U | 0.038 | U | 0.093 | U |
| J009K3 | 18-Nov-02 | SG8-13 | 0.095 | U | 0.07 | U | 0.14 | U |
| Mean (LV) ==========> | | | 0.07 | | 0.11 | | 0.24 | |
| Standard Deviation (S) ==========> | | | 0.03 | | 0.16 | | 0.35 | |
| α (5%) ==========> | | | 1.645 | | 1.645 | | 1.645 | |
| β (20%) ==========> | | | 0.842 | | 0.842 | | 0.842 | |
| Number of Samples ==========> | | | 1 | | 1 | | 1 | |

Shallow Zone

## CALCULATION SHEET

Bechtel Hanford Inc.

**Originator** M. T. Stankovich **Date** 3/18/2003 **Calc. No.** 0100F-CA-V0150 **Rev. No.** 0
**Project** Group 4 Remedial Action **Job No.** 22192 **Checked** SW Callison SWC **Date** 3-19-03
**Subject** 116-F-1 Lewis Canal Trench Sample Variance **Sheet No.** 5 of 11

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-V0156.
Mean, Standard Deviation, *t*, and Number of Samples formulas are from DOE/RL-96-22, Appendix A.

Decision Unit: Overburden Zone
Samples values from GEA analysis
Sample Areas A & B

| Sample # | Sample Date | Location | Cobalt-60 pCi/g | Q | Cesium-137 pCi/g | Q | Europium-152 pCi/g | Q |
|---|---|---|---|---|---|---|---|---|
| Look-up Value (HT) ==========> | | | 1.4 | | 6.200 | | 3.300 | |
| J008R0 | 11/12/02 | O-A1-2 | 0.120 | U | 0.096 | U | 0.190 | U |
| J008R1 | 11/12/02 | O-A1-3 | 0.064 | U | 0.074 | U | 0.130 | U |
| J008R2 | 11/12/02 | O-A1-4 | 0.078 | U | 0.076 | U | 0.150 | U |
| J008R3 | 11/12/02 | O-A1-10 | 0.076 | U | 0.073 | U | 0.150 | U |
| J008R4 | 11/12/02 | O-A1-13 | 0.058 | U | 0.051 | U | 0.130 | U |
| J008R5 | 11/12/02 | O-A1-16 | 0.045 | U | 0.054 | U | 0.110 | U |
| J008R6 | 11/12/02 | O-A2-3 | 0.072 | U | 0.069 | U | 0.160 | U |
| J008R7 | 11/12/02 | O-A2-6 | 0.150 | U | 0.110 | U | 0.260 | U |
| J008R8 | 11/12/02 | O-A2-7 | 0.086 | U | 0.100 | U | 0.210 | U |
| J008R9 | 11/12/02 | O-A2-10 | 0.084 | U | 0.085 | U | 0.180 | U |
| J008T1 | 11/12/02 | O-A2-15 | 0.071 | U | 0.070 | U | 0.190 | U |
| J008T0 | 11/12/02 | O-A2-14 | 0.098 | U | 0.110 | U | 0.280 | U |
| J008T2 | 11/12/02 | O-A3-1 | 0.074 | U | 0.071 | U | 0.140 | U |
| J008T3 | 11/12/02 | O-A3-2 | 0.042 | U | 0.077 | U | 0.100 | U |
| J008T4 | 11/12/02 | O-A3-4 | 0.047 | U | 0.050 | U | 0.110 | U |
| J008T5 | 11/12/02 | O-A3-5 | 0.120 | U | 0.120 | U | 0.270 | U |
| J008T6 | 11/12/02 | O-A3-9 | 0.060 | U | 0.056 | U | 0.120 | U |
| J008T7 | 11/12/02 | O-A4-11 | 0.083 | U | 0.092 | U | 0.190 | U |
| J008T8 | 11/12/02 | O-A4-3 | 0.100 | U | 0.230 | U | 0.260 | U |
| J008T9 | 11/12/02 | O-A4-4 | 0.092 | U | 0.100 | U | 0.200 | U |
| J008V0 | 11/12/02 | O-A4-7 | 0.072 | U | 0.072 | U | 0.160 | U |
| J008V1 | 11/12/02 | O-A4-9 | 0.120 | U | 0.100 | U | 0.210 | U |
| J008V2 | 11/12/02 | O-A4-12 | 0.110 | U | 0.110 | U | 0.230 | U |
| J008V3 | 11/12/02 | O-A4-13 | 0.076 | U | 0.067 | U | 0.150 | U |
| J008V4 | 11/14/02 | O-B5-1 | 0.100 | U | 0.090 | U | 0.160 | U |
| J008V5 | 11/14/02 | O-B5-2 | 0.051 | U | 0.052 | U | 0.120 | U |
| J008V6 | 11/14/02 | O-B5-5 | 0.084 | U | 0.081 | U | 0.190 | U |
| J008V7 | 11/14/02 | O-B5-7 | 0.053 | U | 0.050 | U | 0.120 | U |
| J008V8 | 11/14/02 | O-B5-13 | 0.072 | U | 0.088 | J | 0.140 | U |
| J008V9 | 11/14/02 | O-B5-15 | 0.120 | U | 0.120 | U | 0.220 | U |
| J008W0 | 11/14/02 | O-B6-1 | 0.072 | U | 0.071 | U | 0.160 | U |
| J008W1 | 11/14/02 | O-B6-10 | 0.083 | U | 0.079 | U | 0.190 | U |
| J008W2 | 11/14/02 | O-B6-12 | 0.076 | U | 0.071 | U | 0.160 | U |
| J008W3 | 11/14/02 | O-B6-13 | 0.095 | U | 0.093 | U | 0.180 | U |
| J008W4 | 11/14/02 | O-B6-15 | 0.130 | U | 0.120 | U | 0.220 | U |
| J008W5 | 11/14/02 | O-B6-16 | 0.059 | U | 0.062 | U | 0.140 | U |
| J008W6 | 11/14/02 | O-B7-1 | 0.120 | U | 0.110 | U | 0.230 | U |
| J008W7 | 11/14/02 | O-B7-3 | 0.077 | U | 0.070 | U | 0.160 | U |

Overburden Zone

## CALCULATION SHEET

Bechtel Hanford Inc.

Originator M. T. Stankovich Date 3/18/2003 Calc. No. 0100F-CA-V0150 Rev. No. 0

Project Group 4 Remedial Action Job No. 22192 Checked SW Callison SWC Date 3-19-03

Subject 116-F-1 Lewis Canal Trench Sample Variance Sheet No. 6 of 11

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 54 | J008W8 | 11/14/02 | O-B7-4 | 0.095 | U | 0.083 | U | 0.170 | U |
| 55 | J008W9 | 11/14/02 | O-B7-5 | 0.100 | U | 0.120 | U | 0.170 | U |
| 56 | J008X0 | 11/14/02 | O-B7-8 | 0.064 | U | 0.094 | U | 0.150 | U |
| 57 | J008X1 | 11/14/02 | O-B7-11 | 0.100 | U | 0.097 | U | 0.200 | U |
| 58 | J008X2 | 11/14/02 | O-B8-2 | 0.068 | U | 0.069 | U | 0.160 | U |
| 59 | J008X3 | 11/14/02 | O-B8-3 | 0.072 | U | 0.075 | U | 0.190 | U |
| 60 | J008X4 | 11/14/02 | O-B8-4 | 0.120 | U | 0.110 | U | 0.270 | U |
| 61 | J008X5 | 11/14/02 | O-B8-8 | 0.080 | U | 0.060 | U | 0.170 | U |
| 62 | J008X6 | 11/14/02 | O-B8-12 | 0.084 | U | 0.096 | U | 0.170 | U |
| 63 | J008X7 | 11/14/02 | O-B8-13 | 0.062 | U | 0.108 | | 0.130 | U |
| 64 | Mean (LV) ==========> | | | 0.08 | | 0.088 | | 0.178 | |
| 65 | Standard Deviation (S) ==========> | | | 0.03 | | 0.036 | | 0.053 | |
| 66 | α (5%) ==========> | | | 1.645 | | 1.645 | | 1.645 | |
| 67 | β (20%) ==========> | | | 0.842 | | 0.842 | | 0.842 | |
| 68 | **Number of Samples ==========>** | | | **1** | | **1** | | **1** | |

Overburden Zone

**CALCULATION**

Bechtel Hanford Inc.

**Originator** M. T. Stankovich Date 3/18/2003 Calc. No. 0100F-CA-V0150 Rev. No. 0
**Project** Group 4 Remedial Action Job No. 22192 Checked SW Callison Date 3-18-03
**Subject** 116-F-1 Lewis Canal Trench Sample Variance Sheet No. 7 of 11

| | samp_num | samp_date | Sample Node | Co60 | Q | Cs137 | Q | Eu152 | Q |
|---|---|---|---|---|---|---|---|---|---|
| 1 | J008Y6 | 10-Dec-02 | SA1-2 | 0.045 | U | 0.228 | | 0.095 | U |
| 2 | J008Y7 | 10-Dec-02 | SA1-3 | 0.095 | U | 0.088 | U | 0.149 | U |
| 3 | J008Y8 | 10-Dec-02 | SA1-4 | 0.063 | U | 0.195 | | 0.18 | U |
| 4 | J008Y9 | 10-Dec-02 | SA1-10 | 0.051 | U | 0.138 | | 0.1 | U |
| 5 | J00900 | 10-Dec-02 | SA1-14 | 0.035 | U | 0.048 | | 0.088 | U |
| 6 | J00901 | 10-Dec-02 | SA1-16 | 0.048 | U | 0.095 | | 0.12 | U |
| 7 | J00902 | 10-Dec-02 | SA2-3 | 0.057 | U | 0.222 | | 0.13 | U |
| 8 | J00903 | 10-Dec-02 | SA2-6 | 0.082 | U | 0.117 | | 0.18 | U |
| 9 | J00904 | 10-Dec-02 | SA2-7 | 0.086 | U | 0.189 | | 0.19 | U |
| 10 | J00905 | 10-Dec-02 | SA2-10 | 0.046 | U | 0.13 | | 0.13 | U |
| 11 | J00906 | 10-Dec-02 | SA2-14 | 0.048 | U | 0.067 | U | 0.13 | U |
| 12 | J00907 | 10-Dec-02 | SA2-15 | 0.081 | U | 0.124 | | 0.15 | U |
| 13 | J00908 | 10-Dec-02 | SA3-1 | 0.065 | U | 0.061 | U | 0.14 | U |
| 14 | J00909 | 10-Dec-02 | SA3-2 | 0.058 | U | 0.052 | U | 0.13 | U |
| 15 | J00910 | 10-Dec-02 | SA3-4 | 0.084 | U | 0.081 | U | 0.18 | U |
| 16 | J00911 | 10-Dec-02 | SA3-5 | 0.067 | U | 0.067 | U | 0.15 | U |
| 17 | J00912 | 10-Dec-02 | SA3-9 | 0.059 | U | 0.056 | U | 0.13 | U |
| 18 | J00913 | 10-Dec-02 | SA3-11 | 0.07 | U | 0.073 | U | 0.2 | U |
| 19 | J00914 | 10-Dec-02 | SA4-3 | 0.05 | U | 0.045 | U | 0.1 | U |
| 20 | J00915 | 10-Dec-02 | SA4-4 | 0.056 | U | 0.051 | U | 0.11 | U |
| 21 | J00916 | 10-Dec-02 | SA4-7 | 0.039 | U | 0.041 | U | 0.094 | U |
| 22 | J00917 | 10-Dec-02 | SA4-9 | 0.043 | U | 0.036 | U | 0.083 | U |
| 23 | J00918 | 10-Dec-02 | SA4-12 | 0.063 | U | 0.05 | U | 0.15 | U |
| 24 | J00919 | 10-Dec-02 | SA4-13 | 0.038 | U | 0.034 | U | 0.085 | U |
| 25 | J00920 | 10-Dec-02 | SB5-1 | 0.061 | U | 0.049 | U | 0.12 | U |
| 26 | J00921 | 10-Dec-02 | SB5-2 | 0.061 | U | 0.058 | U | 0.13 | U |
| 27 | J00922 | 10-Dec-02 | SB5-5 | 0.047 | U | 0.043 | U | 0.11 | U |
| 28 | J00923 | 10-Dec-02 | SB5-7 | 0.053 | U | 0.049 | U | 0.12 | U |
| 29 | J00924 | 10-Dec-02 | SB5-13 | 0.063 | U | 0.077 | U | 0.17 | U |
| 30 | J00925 | 10-Dec-02 | SB5-15 | 0.064 | U | 0.053 | U | 0.12 | U |
| 31 | J00926 | 10-Dec-02 | SB6-1 | 0.231 | | 1.28 | | 2.420 | |
| 32 | J00927 | 10-Dec-02 | SB6-10 | 0.054 | U | 0.048 | U | 0.12 | U |
| 33 | J00928 | 10-Dec-02 | SB6-12 | 0.062 | U | 0.092 | U | 0.2 | U |
| 34 | J00929 | 10-Dec-02 | SB6-13 | 0.049 | U | 0.041 | U | 0.11 | U |
| 35 | J00930 | 10-Dec-02 | SB6-15 | 0.068 | U | 0.064 | U | 0.14 | U |
| 36 | J00931 | 10-Dec-02 | SB6-16 | 0.05 | U | 0.043 | U | 0.12 | U |
| 37 | J00932 | 10-Dec-02 | SB7-1 | 0.053 | U | 0.05 | U | 0.12 | U |
| 38 | J00933 | 10-Dec-02 | SB7-3 | 0.058 | U | 0.053 | U | 0.13 | U |
| 39 | J00934 | 10-Dec-02 | SB7-4 | 0.075 | U | 0.053 | U | 0.15 | U |
| 40 | J00935 | 10-Dec-02 | SB7-5 | 0.071 | U | 0.073 | | 0.26 | |
| 41 | J00936 | 10-Dec-02 | SB7-8 | 0.053 | U | 0.052 | U | 0.13 | U |
| 42 | J00937 | 10-Dec-02 | SB7-11 | 0.044 | U | 0.052 | U | 0.12 | U |
| 43 | J00938 | 10-Dec-02 | SB8-2 | 0.043 | U | 0.036 | U | 0.087 | U |
| 44 | J00939 | 10-Dec-02 | SB8-3 | 0.036 | U | 0.036 | U | 0.084 | U |
| 45 | J00940 | 10-Dec-02 | SB8-4 | 0.042 | U | 0.045 | U | 0.11 | U |
| 46 | J00941 | 10-Dec-02 | SB8-8 | 0.041 | U | 0.058 | U | 0.092 | U |
| 47 | J00942 | 10-Dec-02 | SB8-12 | 0.029 | U | 0.033 | U | 0.078 | U |
| 48 | J00943 | 10-Dec-02 | SB8-13 | 0.034 | U | 0.033 | U | 0.081 | U |
| 49 | J00944 | 09-Dec-02 | SC9-3 | 0.13 | U | 0.13 | | 0.406 | |
| 50 | J00945 | 09-Dec-02 | SC9-4 | 0.055 | U | 0.048 | | 0.105 | |
| 51 | J00946 | 09-Dec-02 | SC9-5 | 0.082 | U | 0.062 | U | 0.16 | U |
| 52 | J00947 | 09-Dec-02 | SC9-10 | 0.052 | U | 0.044 | U | 0.11 | U |
| 53 | J00948 | 09-Dec-02 | SC9-14 | 0.1 | | 0.83 | | 1.48 | |

Shallow Zone Data

**CALCULATION**

Bechtel Hanford Inc.

| | | | | | |
|---|---|---|---|---|---|
| **Originator** | M. T. Stankovich | Date 3/18/2003 | Calc. No. | 0100F-CA-V0150 | Rev. No. 0 |
| **Project** | Group 4 Remedial Action | Job No. 22192 | Checked | SW Callison SWC | Date 3-18-03 |
| **Subject** | 116-F-1 Lewis Canal Trench Sample Variance | | | | Sheet No. 8 of 11 |

| | samp_num | samp_date | Sample Node | Co60 | Q | Cs137 | Q | Eu152 | Q |
|---|---|---|---|---|---|---|---|---|---|
| 54 | J00949 | 09-Dec-02 | SC9-16 | 0.11 | U | 0.181 | | 0.29 | U |
| 55 | J00950 | 09-Dec-02 | SC10-3 | 0.052 | U | 0.045 | U | 0.11 | U |
| 56 | J00951 | 09-Dec-02 | SC10-4 | 0.074 | U | 0.059 | U | 0.14 | U |
| 57 | J00952 | 09-Dec-02 | SC10-8 | 0.12 | U | 0.384 | | 0.744 | |
| 58 | J00953 | 09-Dec-02 | SC10-10 | 0.061 | U | 0.078 | U | 0.481 | |
| 59 | J00954 | 09-Dec-02 | SC10-14 | 0.05 | U | 0.051 | U | 0.11 | U |
| 60 | J00955 | 09-Dec-02 | SC10-16 | 0.067 | U | 0.167 | | 0.442 | |
| 61 | J00956 | 09-Dec-02 | SC1-2 | 0.13 | U | 0.444 | | 0.756 | |
| 62 | J00957 | 09-Dec-02 | SC1-3 | 0.044 | U | 0.047 | U | 0.12 | U |
| 63 | J00958 | 09-Dec-02 | SC1-4 | 0.17 | U | 0.74 | | 1.26 | |
| 64 | J00959 | 09-Dec-02 | SC1-10 | 0.1 | U | 0.608 | | 1.34 | |
| 65 | J00960 | 09-Dec-02 | SC1-13 | 0.06 | U | 0.087 | | 0.081 | U |
| 66 | J00961 | 09-Dec-02 | SC1-16 | 0.058 | U | 0.065 | U | 0.15 | U |
| 67 | J00962 | 09-Dec-02 | SC2-3 | 0.074 | U | 0.323 | | 0.673 | |
| 68 | J00963 | 09-Dec-02 | SC2-6 | 0.085 | U | 0.384 | | 0.733 | |
| 69 | J00964 | 09-Dec-02 | SC2-7 | 0.076 | U | 0.082 | | 0.165 | |
| 70 | J00965 | 09-Dec-02 | SC2-10 | 0.059 | U | 0.057 | U | 0.13 | U |
| 71 | J00966 | 09-Dec-02 | SC2-14 | 0.13 | U | 0.441 | | 1.35 | |
| 72 | J00967 | 09-Dec-02 | SC2-15 | 0.069 | U | 0.242 | | 0.482 | |
| 73 | J00968 | 19-Nov-02 | SD3-1 | 0.091 | U | 0.083 | U | 0.2 | U |
| 74 | J00969 | 19-Nov-02 | SD3-2 | 0.062 | U | 0.062 | U | 0.15 | U |
| 75 | J00970 | 19-Nov-02 | SD3-4 | 0.1 | U | 0.085 | U | 0.23 | U |
| 76 | J00971 | 19-Nov-02 | SD3-5 | 0.067 | U | 0.07 | U | 0.14 | U |
| 77 | J00972 | 19-Nov-02 | SD3-9 | 0.067 | U | 0.064 | U | 0.14 | U |
| 78 | J00973 | 19-Nov-02 | SD3-11 | 0.12 | U | 0.13 | U | 0.25 | U |
| 79 | J00974 | 19-Nov-02 | SD4-3 | 0.081 | U | 0.082 | U | 0.19 | U |
| 80 | J00975 | 19-Nov-02 | SD4-4 | 0.11 | U | 0.07 | U | 0.2 | U |
| 81 | J00976 | 19-Nov-02 | SD4-7 | 0.078 | U | 0.077 | U | 0.17 | U |
| 82 | J00977 | 19-Nov-02 | SD4-9 | 0.077 | U | 0.057 | U | 0.14 | U |
| 83 | J00978 | 19-Nov-02 | SD4-12 | 0.12 | U | 0.11 | U | 0.21 | U |
| 84 | J00979 | 19-Nov-02 | SD4-13 | 0.054 | U | 0.063 | U | 0.15 | U |
| 85 | J00980 | 19-Nov-02 | SD5-1 | 0.11 | U | 0.087 | U | 0.26 | U |
| 86 | J00981 | 19-Nov-02 | SD5-2 | 0.052 | U | 0.052 | U | 0.12 | U |
| 87 | J00982 | 19-Nov-02 | SD5-5 | 0.067 | U | 0.068 | U | 0.14 | U |
| 88 | J00983 | 19-Nov-02 | SD5-7 | 0.087 | U | 0.077 | U | 0.15 | U |
| 89 | J00984 | 19-Nov-02 | SD5-13 | 0.099 | U | 0.071 | U | 0.19 | U |
| 90 | J00985 | 19-Nov-02 | SD5-15 | 0.083 | U | 0.171 | | 0.429 | |
| 91 | J00986 | 19-Nov-02 | SD6-1 | 0.053 | U | 0.054 | U | 0.13 | U |
| 92 | J00987 | 19-Nov-02 | SD6-10 | 0.051 | U | 0.048 | U | 0.11 | U |
| 93 | J00988 | 19-Nov-02 | SD6-12 | 0.073 | U | 0.062 | U | 0.14 | U |
| 94 | J00989 | 19-Nov-02 | SD6-13 | 0.047 | U | 0.227 | | 0.458 | |
| 95 | J00990 | 19-Nov-02 | SD6-15 | 0.084 | U | 0.063 | U | 0.17 | U |
| 96 | J00991 | 19-Nov-02 | SD6-16 | 0.041 | U | 0.044 | U | 0.1 | U |
| 97 | J00992 | 19-Nov-02 | SE7-1 | 0.069 | U | 0.056 | U | 0.12 | U |
| 98 | J00993 | 19-Nov-02 | SE7-3 | 0.036 | U | 0.036 | U | 0.088 | U |
| 99 | J00994 | 19-Nov-02 | SE7-4 | 0.054 | U | 0.06 | U | 0.14 | U |
| 100 | J00995 | 19-Nov-02 | SE7-5 | 0.041 | U | 0.037 | U | 0.089 | U |
| 101 | J00996 | 19-Nov-02 | SE7-8 | 0.057 | U | 0.049 | U | 0.11 | U |
| 102 | J00997 | 19-Nov-02 | SE7-11 | 0.13 | U | 0.11 | U | 0.22 | U |
| 103 | J00998 | 19-Nov-02 | SE8-2 | 0.055 | U | 0.043 | U | 0.14 | U |
| 104 | J00999 | 19-Nov-02 | SE8-3 | 0.089 | U | 0.07 | U | 0.18 | U |
| 105 | J009B0 | 19-Nov-02 | SE8-4 | 0.096 | U | 0.729 | | 0.979 | |
| 106 | J009B1 | 19-Nov-02 | SE8-8 | 0.096 | U | 0.084 | U | 0.18 | U |

Shallow Zone Data

**CALCULATION**

Bechtel Hanford Inc.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Originator | M. T. Stankovich | Date | 3/18/2003 | Calc. No. | 0100F-CA-V0150 | Rev. No. | 0 |
| Project | Group 4 Remedial Action | Job No. | 22192 | Checked | SW Calligan SWC | Date | 3-18-03 |
| Subject | 116-F-1 Lewis Canal Trench Sample Variance | | | | | Sheet No. | 9 of 11 |

| | samp_num | samp_date | Sample Node | Co60 | Q | Cs137 | Q | Eu152 | Q |
|---|---|---|---|---|---|---|---|---|---|
| 107 | J009B2 | 19-Nov-02 | SE8-12 | 0.062 | U | 0.048 | U | 0.12 | U |
| 108 | J009B3 | 19-Nov-02 | SE8-13 | 0.039 | U | 0.037 | U | 0.09 | U |
| 109 | J009B4 | 19-Nov-02 | SE9-3 | 0.074 | U | 0.055 | U | 0.15 | U |
| 110 | J009B5 | 19-Nov-02 | SE9-4 | 0.062 | U | 0.396 | | 0.858 | |
| 111 | J009B6 | 19-Nov-02 | SE9-5 | 0.043 | U | 0.04 | U | 0.1 | U |
| 112 | J009B7 | 19-Nov-02 | SE9-10 | 0.068 | U | 0.052 | U | 0.13 | U |
| 113 | J009B8 | 19-Nov-02 | SE9-14 | 0.038 | U | 0.035 | U | 0.094 | U |
| 114 | J009B9 | 19-Nov-02 | SE9-16 | 0.059 | U | 0.053 | U | 0.13 | U |
| 115 | J009C0 | 19-Nov-02 | SE10-3 | 0.04 | U | 0.037 | U | 0.093 | U |
| 116 | J009C1 | 19-Nov-02 | SE10-4 | 0.048 | U | 0.045 | U | 0.1 | U |
| 117 | J009C2 | 19-Nov-02 | SE10-8 | 0.078 | U | 0.064 | U | 0.13 | U |
| 118 | J009C3 | 19-Nov-02 | SE10-10 | 0.043 | U | 0.044 | U | 0.11 | U |
| 119 | J009C4 | 19-Nov-02 | SE10-14 | 0.11 | U | 0.083 | U | 0.22 | U |
| 120 | J009C5 | 19-Nov-02 | SE10-16 | 0.057 | U | 0.055 | U | 0.13 | U |
| 121 | J009C6 | 18-Nov-02 | SF1-2 | 0.14 | U | 0.248 | | 0.363 | |
| 122 | J009C7 | 18-Nov-02 | SF1-3 | 0.061 | U | 0.063 | U | 0.15 | U |
| 123 | J009C8 | 18-Nov-02 | SF1-4 | 0.13 | U | 0.11 | U | 0.27 | U |
| 124 | J009C9 | 18-Nov-02 | SF1-10 | 0.054 | U | 0.062 | U | 0.14 | U |
| 125 | J009D0 | 18-Nov-02 | SF1-13 | 0.1 | U | 0.074 | U | 0.17 | U |
| 126 | J009D1 | 18-Nov-02 | SF1-16 | 0.098 | U | 0.086 | U | 0.19 | U |
| 127 | J009D2 | 18-Nov-02 | SF2-3 | 0.04 | U | 0.067 | U | 0.1 | U |
| 128 | J009D3 | 18-Nov-02 | SF2-6 | 0.074 | U | 0.068 | U | 0.16 | U |
| 129 | J009D4 | 18-Nov-02 | SF2-7 | 0.037 | U | 0.036 | U | 0.081 | U |
| 130 | J009D5 | 18-Nov-02 | SF2-10 | 0.064 | U | 0.055 | U | 0.16 | U |
| 131 | J009D6 | 18-Nov-02 | SF2-14 | 0.077 | U | 0.085 | U | 0.17 | U |
| 132 | J009D7 | 18-Nov-02 | SF2-15 | 0.051 | U | 0.092 | U | 0.093 | |
| 133 | J009D8 | 18-Nov-02 | SF3-1 | 0.089 | U | 0.066 | U | 0.19 | U |
| 134 | J009D9 | 18-Nov-02 | SF3-2 | 0.07 | U | 0.067 | U | 0.15 | U |
| 135 | J009F0 | 18-Nov-02 | SF3-4 | 0.079 | U | 0.081 | U | 0.2 | U |
| 136 | J009F1 | 18-Nov-02 | SF3-5 | 0.081 | U | 0.087 | U | 0.16 | U |
| 137 | J009F2 | 18-Nov-02 | SF3-9 | 0.051 | U | 0.045 | U | 0.11 | U |
| 138 | J009F3 | 18-Nov-02 | SF3-11 | 0.12 | U | 0.224 | | 0.688 | |
| 139 | J009F4 | 18-Nov-02 | SF4-3 | 0.065 | U | 0.064 | U | 0.15 | U |
| 140 | J009F5 | 18-Nov-02 | SF4-4 | 0.082 | U | 0.06 | U | 0.16 | U |
| 141 | J009F6 | 18-Nov-02 | SF4-7 | 0.049 | U | 0.044 | U | 0.098 | U |
| 142 | J009F7 | 18-Nov-02 | SF4-8 | 0.034 | U | 0.028 | U | 0.078 | U |
| 143 | J009F8 | 18-Nov-02 | SF4-12 | 0.059 | U | 0.052 | U | 0.13 | U |
| 144 | J009F9 | 18-Nov-02 | SF4-13 | 0.228 | | 0.705 | | 2.77 | |
| 145 | J009H0 | 18-Nov-02 | SG5-1 | 0.071 | U | 0.061 | U | 0.14 | U |
| 146 | J009H1 | 18-Nov-02 | SG5-2 | 0.033 | U | 0.036 | U | 0.088 | U |
| 147 | J009H2 | 18-Nov-02 | SG5-5 | 0.066 | U | 0.047 | U | 0.14 | U |
| 148 | J009H3 | 18-Nov-02 | SG5-7 | 0.043 | U | 0.04 | U | 0.095 | U |
| 149 | J009H4 | 18-Nov-02 | SG5-13 | 0.043 | U | 0.04 | U | 0.094 | U |
| 150 | J009H5 | 18-Nov-02 | SG5-15 | 0.1 | U | 0.073 | U | 0.17 | U |
| 151 | J009H6 | 18-Nov-02 | SG6-1 | 0.051 | U | 0.044 | U | 0.11 | U |
| 152 | J009H7 | 18-Nov-02 | SG6-10 | 0.089 | U | 0.057 | U | 0.206 | |
| 153 | J009H8 | 10-Dec-02 | SG6-12 | 0.073 | U | 0.072 | U | 0.14 | U |
| 154 | J009H9 | 18-Nov-02 | SG6-13 | 0.05 | U | 0.042 | U | 0.1 | U |
| 155 | J009J0 | 10-Dec-02 | SG6-15 | 0.065 | U | 0.082 | | 0.16 | U |
| 156 | J009J1 | 10-Dec-02 | SG6-16 | 0.058 | U | 0.057 | | 0.12 | U |
| 157 | J009J2 | 18-Nov-02 | SG7-1 | 0.065 | U | 0.057 | U | 0.14 | U |
| 158 | J009J3 | 18-Nov-02 | SG7-3 | 0.069 | U | 0.07 | U | 0.13 | U |
| 159 | J009J4 | 18-Nov-02 | S-G7-4 | 0.046 | U | 0.045 | U | 0.11 | U |

Shallow Zone Data

**CALCULATION**

Bechtel Hanford Inc.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Originator | M. T. Stankovich | Date 3/18/2003 | Calc. No. | 0100F-CA-V0150 | Rev. No. | 0 |
| Project | Group 4 Remedial Action | Job No. 22192 | Checked | SW Callison SWC | Date | 3-18-03 |
| Subject | 116-F-1 Lewis Canal Trench Sample Variance | | | | Sheet No. | 10 of 11 |

| | samp_num | samp_date | Sample Node | Co60 | Q | Cs137 | Q | Eu152 | Q |
|---|---|---|---|---|---|---|---|---|---|
| 160 | J009J5 | 18-Nov-02 | S-G7-5 | 0.071 | U | 0.073 | U | 0.16 | U |
| 161 | J009J6 | 18-Nov-02 | S-G7-8 | 0.049 | U | 0.052 | U | 0.11 | U |
| 162 | J009J7 | 18-Nov-02 | S-G7-11 | 0.061 | U | 0.049 | U | 0.13 | U |
| 163 | J009J8 | 18-Nov-02 | S-G8-2 | 0.064 | U | 0.044 | U | 0.11 | U |
| 164 | J009J9 | 18-Nov-02 | SG8-3 | 0.038 | U | 0.047 | U | 0.173 | |
| 165 | J009K0 | 18-Nov-02 | SG8-4 | 0.065 | U | 0.062 | U | 0.15 | U |
| 166 | J009K1 | 18-Nov-02 | SG8-8 | 0.043 | U | 0.037 | U | 0.087 | U |
| 167 | J009K2 | 18-Nov-02 | SG8-12 | 0.047 | U | 0.038 | U | 0.093 | U |
| 168 | J009K3 | 18-Nov-02 | SG8-13 | 0.095 | U | 0.07 | U | 0.14 | U |

Shallow Zone Data

**CALCULATION**

Bechtel Hanford Inc.

**Originator** M. T. Stankovich **Date** 3/18/2003 **Calc. No.** 0100F-CA-V0150 **Rev. No.** 0
**Project** Group 4 Remedial Action **Job No.** 22192 **Checked** SW Callison SWC **Date** 3-19-03
**Subject** 116-F-1 Lewis Canal Trench Sample Variance **Sheet No.** 11 of 11

| | samp_num | samp_date | Sample Node | Co60 | Q | Cs137 | Q | Eu152 | Q |
|---|---|---|---|---|---|---|---|---|---|
| 1 | J008R0 | 11/12/2002 | O-A1-2 | 0.12 | U | 0.096 | U | 0.19 | U |
| 2 | J008R1 | 11/12/2002 | O-A1-3 | 0.064 | U | 0.074 | U | 0.13 | U |
| 3 | J008R2 | 11/12/2002 | O-A1-4 | 0.078 | U | 0.076 | U | 0.15 | U |
| 4 | J008R3 | 11/12/2002 | O-A1-10 | 0.076 | U | 0.073 | U | 0.15 | U |
| 5 | J008R4 | 11/12/2002 | O-A1-13 | 0.058 | U | 0.051 | U | 0.13 | U |
| 6 | J008R5 | 11/12/2002 | O-A1-16 | 0.045 | U | 0.054 | U | 0.11 | U |
| 7 | J008R6 | 11/12/2002 | O-A2-3 | 0.072 | U | 0.069 | U | 0.16 | U |
| 8 | J008R7 | 11/12/2002 | O-A2-6 | 0.15 | U | 0.11 | U | 0.26 | U |
| 9 | J008R8 | 11/12/2002 | O-A2-7 | 0.086 | U | 0.1 | U | 0.21 | U |
| 10 | J008R9 | 11/12/2002 | O-A2-10 | 0.084 | U | 0.085 | U | 0.18 | U |
| 11 | J008T1 | 11/12/2002 | O-A2-15 | 0.071 | U | 0.07 | U | 0.19 | U |
| 12 | J008T0 | 11/12/2002 | O-A2-14 | 0.098 | U | 0.11 | U | 0.28 | U |
| 13 | J008T2 | 11/12/2002 | O-A3-1 | 0.074 | U | 0.071 | U | 0.14 | U |
| 14 | J008T3 | 11/12/2002 | O-A3-2 | 0.042 | U | 0.077 | U | 0.1 | U |
| 15 | J008T4 | 11/12/2002 | O-A3-4 | 0.047 | U | 0.05 | U | 0.11 | U |
| 16 | J008T5 | 11/12/2002 | O-A3-5 | 0.12 | U | 0.12 | U | 0.27 | U |
| 17 | J008T6 | 11/12/2002 | O-A3-9 | 0.06 | U | 0.056 | U | 0.12 | U |
| 18 | J008T7 | 11/12/2002 | O-A4-11 | 0.083 | U | 0.092 | U | 0.19 | U |
| 19 | J008T8 | 11/12/2002 | O-A4-3 | 0.1 | U | 0.23 | U | 0.26 | U |
| 20 | J008T9 | 11/12/2002 | O-A4-4 | 0.092 | U | 0.1 | U | 0.2 | U |
| 21 | J008V0 | 11/12/2002 | O-A4-7 | 0.072 | U | 0.072 | U | 0.16 | U |
| 22 | J008V1 | 11/12/2002 | O-A4-9 | 0.12 | U | 0.1 | U | 0.21 | U |
| 23 | J008V2 | 11/12/2002 | O-A4-12 | 0.11 | U | 0.11 | U | 0.23 | U |
| 24 | J008V3 | 11/12/2002 | O-A4-13 | 0.076 | U | 0.067 | U | 0.15 | U |
| 25 | J008V4 | 11/14/2002 | O-B5-1 | 0.1 | U | 0.09 | U | 0.16 | U |
| 26 | J008V5 | 11/14/2002 | O-B5-2 | 0.051 | U | 0.052 | U | 0.12 | U |
| 27 | J008V6 | 11/14/2002 | O-B5-5 | 0.084 | U | 0.081 | U | 0.19 | U |
| 28 | J008V7 | 11/14/2002 | O-B5-7 | 0.053 | U | 0.05 | U | 0.12 | U |
| 29 | J008V8 | 11/14/2002 | O-B5-13 | 0.072 | U | .08800 | J | 0.14 | U |
| 30 | J008V9 | 11/14/2002 | O-B5-15 | 0.12 | U | 0.12 | U | 0.22 | U |
| 31 | J008W0 | 11/14/2002 | O-B6-1 | 0.072 | U | 0.071 | U | 0.16 | U |
| 32 | J008W1 | 11/14/2002 | O-B6-10 | 0.083 | U | 0.079 | U | 0.19 | U |
| 33 | J008W2 | 11/14/2002 | O-B6-12 | 0.076 | U | 0.071 | U | 0.16 | U |
| 34 | J008W3 | 11/14/2002 | O-B6-13 | 0.095 | U | 0.093 | U | 0.18 | U |
| 35 | J008W4 | 11/14/2002 | O-B6-15 | 0.13 | U | 0.12 | U | 0.22 | U |
| 36 | J008W5 | 11/14/2002 | O-B6-16 | 0.059 | U | 0.062 | U | 0.14 | U |
| 37 | J008W6 | 11/14/2002 | O-B7-1 | 0.12 | U | 0.11 | U | 0.23 | U |
| 38 | J008W7 | 11/14/2002 | O-B7-3 | 0.077 | U | 0.07 | U | 0.16 | U |
| 39 | J008W8 | 11/14/2002 | O-B7-4 | 0.095 | U | 0.083 | U | 0.17 | U |
| 40 | J008W9 | 11/14/2002 | O-B7-5 | 0.1 | U | 0.12 | U | 0.17 | U |
| 41 | J008X0 | 11/14/2002 | O-B7-8 | 0.064 | U | 0.094 | U | 0.15 | U |
| 42 | J008X1 | 11/14/2002 | O-B7-11 | 0.1 | U | 0.097 | U | 0.2 | U |
| 43 | J008X2 | 11/14/2002 | O-B8-2 | 0.068 | U | 0.069 | U | 0.16 | U |
| 44 | J008X3 | 11/14/2002 | O-B8-3 | 0.072 | U | 0.075 | U | 0.19 | U |
| 45 | J008X4 | 11/14/2002 | O-B8-4 | 0.12 | U | 0.11 | U | 0.27 | U |
| 46 | J008X5 | 11/14/2002 | O-B8-8 | 0.08 | U | 0.06 | U | 0.17 | U |
| 47 | J008X6 | 11/14/2002 | O-B8-12 | 0.084 | U | 0.096 | U | 0.17 | U |
| 48 | J008X7 | 11/14/2002 | O-B8-13 | 0.062 | U | .10800 | | 0.13 | U |

Overburden Zone Data

# CALCULATION COVER SHEET

| | | | |
|---|---|---|---|
| **Project Title:** | **Lewis Canal Trench/Overburden Sample Design** | **Job No.** | **22192** |
| **Area** | **100-F** | | |
| **Discipline** | **Environmental Engineering** | **Calc. No.** | **0100F-CA-V0154** |
| **Subject** | **Lewis Canal Trench/Overburden Sampling Design** | | |
| **Computer Program** | **Excel** | **Program No.** | **Excel 97** |

Use of this calculation by persons who do not have access to all of the pertinent facts could lead to incorrect conclusions or assumptions. Before applying this calculation in your work, this calculation must be thoroughly reviewed with appropriate and authorized Hanford site ERC personnel. Without this review, the ERC cannot assume any responsibility for the use of these calculations.

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

| Rev. | Sheet Numbers | Originator | Checker | Reviewer | Approval | Date |
|---|---|---|---|---|---|---|
| 0 | Cover = 1 Sht<br>Calc = 2 Shts<br>Attach1 = 1 Sht<br>Attach2 = 1 Sht<br>Attach 3 = 2 Shts<br>Total = 7 Shts | G. Cruz<br>2/6/03 | C.A. Bentz<br>2/6/03 | M.T. Stankovich<br>2/13/03 | M.A. Buckmaster<br>2/14/03 | 2/14/03 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**SUMMARY OF REVISIONS**

| | |
|---|---|
| | |
| | |

*Obtain Calc. No. from DIS

DE01-437.03

January 2003

**Bechtel Hanford, Inc.** **CALCULATION SHEET**



**Originator** G. Cruz **Date** 12/6/2002 **Calc. No.** 0100F-CA-V0154 **Rev. No.** 0

**Project** Lewis Canal Trench/Overburden Sample Design **Job No.** 22192 **Checked** CB **Date** 12/2/02

**Subject** Lewis Canal Trench/Overburden Sampling Design **Sheet No.**

**Problem:** Calculate and display required sampling nodes in concurrence with 100 Area SAP DOE/RL-96-22 Rev. 3 for verification and closure.

**Given:**
-SAP (DOE/RL-96-22 Rev. 3) and IG (0100X-IG-G0001 Rev. 3) requirements
-Overburden Sampling Area (Surface area of each zone determined from CAD program, Attachment 3, Sht 1 of 2, CAD file 1F:110502A, 116-F-1 Lewis Canal Trench Overburden Sampling Plan)
-Shallow Zone Sampling Area (Surface area of each zone determined from CAD program, Attachment 3, Sht 2 of 2, CAD file 1F:120602A, 116-F-1 Lewis Canal Trench Shallow Zone Sampling Plan)

**SAP and IG Requirements:**

Overburden:
-Develop a 16 node sampling grid for the sampling area
-Use appendix A of the IG to determine which six of the sixteen will be sampled to collect HPGe and clean up verification samples

**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: | 6757.16 | $m^2$ |
| Area of Decision Subunits (total area 2 subunits) | 3378.58 | $m^2$ |
| Decision Subunit divided into 4 Sampling Areas: | 844.64 | $m^2$ |
| Sampling Areas divided into a 16 node grid (node numbers 1-16): | 52.79 | $m^2$ |

Nodes to be Sampled (as determined from Attachment 1, Table A-1, Sample Grid Point Lookup Table)
See Attachment 3, Sht 1 of 2, Lewis Canal Trench Overburden Sampling Plan, for Sample Location Table

**Bechtel Hanford, Inc.** **CALCULATION SHEET**



Originator G. Cruz Date 12/6/2002 Calc. No. 0100F-CA-V0154 Rev. No. 0
Project Lewis Canal Trench/Overburden Sample Design Job No. 22192 Checked CAB Date 12/12/02
Subject Lewis Canal Trench/Overburden Sampling Design Sheet No.

**Determination of Shallow Zone Sampling Grid:**

Shallow 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: | 24816.78 | $m^2$ |
| Area of Decision Subunits (total area 7 subunits) | 3545.25 | $m^2$ |
| Decision Subunits divided into 4 Sampling Areas: | 886.31 | $m^2$ |
| Sampling Areas divided into a 16 node grid (node numbers 1-16): | 55.39 | $m^2$ |

Nodes to be Sampled (as determined from Attachment 1, Table A-1, Sample Grid Point Lookup Table)
See Attachment 3, Sht 2 of 2, 116-F-1 Lewis Canal Trench Shallow Zone Sampling Plan, for Sample Location Table

Bechtel Hanford, Inc.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Originator | G. Cruz | Date | 12/6/2002 | Calc. No. | 0100F-CA-V0154 | Rev. No. | 0 |
| Project | Lewis Canal Trench/Overburden Sample Design | | | Job No. | 22192 | Checked | CAB |
| | | | | | | Date | 12/11/02 |
| Subject | Lewis Canal Trench/Overburden Sampling Design | | | | | Sheet No | |

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 |
|---|---|---|---|---|---|---|---|---|---|---|
| HPGe/Closeout | 3 | 6 | 1 | 4 | 5 | 1 | 3 | 3 | 4 | 16 |
| HPGe/Closeout | 4 | 7 | 11 | 3 | 15 | 15 | 5 | 13 | 10 | 10 |
| HPGe/Closeout | 16 | 3 | 2 | 7 | 7 | 10 | 11 | 4 | 3 | 14 |
| HPGe/Closeout | 10 | 15 | 4 | 12 | 1 | 13 | 4 | 8 | 16 | 4 |
| HPGe | 2 | 14 | 5 | 9 | 13 | 12 | 8 | 2 | 14 | 8 |
| HPGe | 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 northwesternmost node. Then number consecutively left to right as shown in Fig. 5-1 of this IG

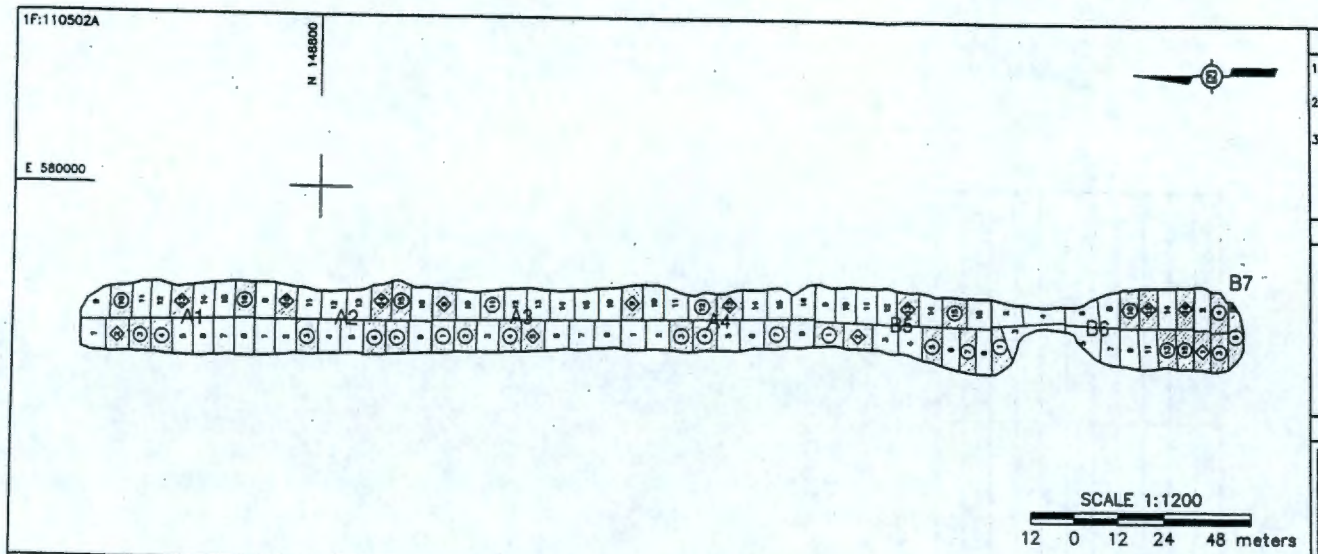
Bechtel Hanford, Inc.

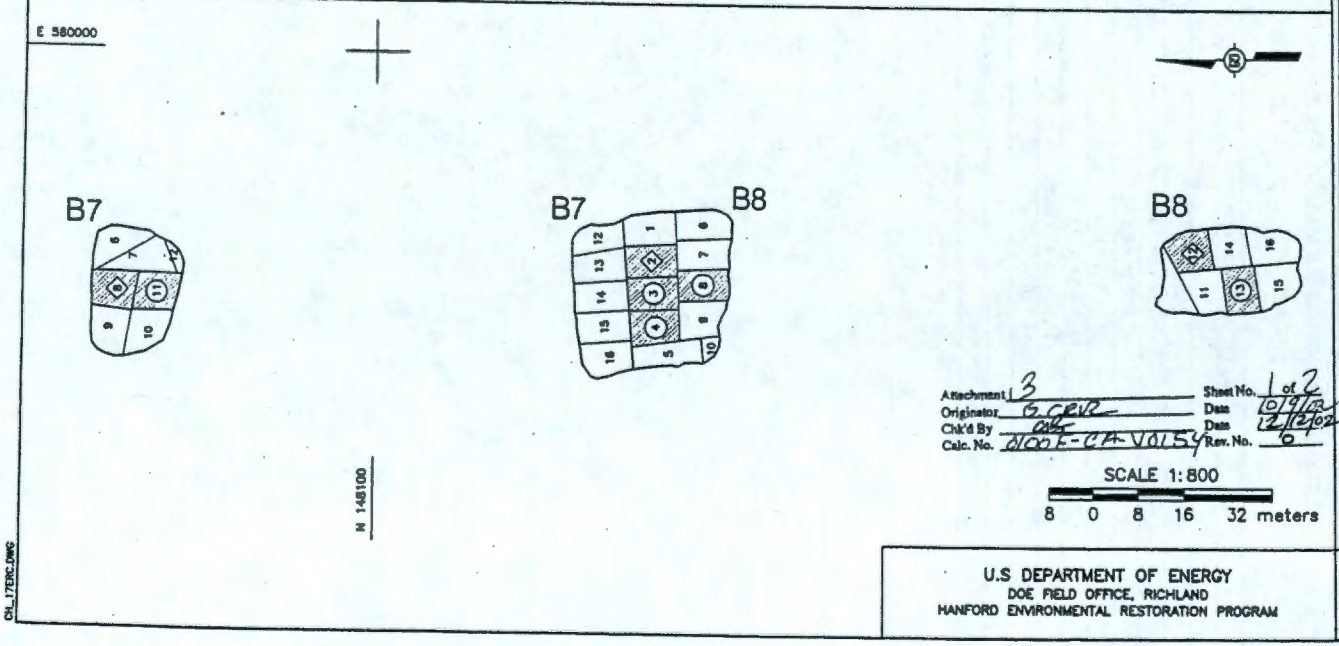
Originator G. Cruz Date 12/6/2002 Calc. No. 0100F-CA-V0154 Rev. No. 0
Project Lewis Canal Trench/Overburden Sample Design Job No. 22192 Checked CSB Date 12/11/02
Subject Lewis Canal Trench/Overburden Sampling Design Sheet No.

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 | ROUNDa (Area/3,720) |
| a ROUND is an integer rounding function. | |




Attachment 3
Originator G. GRIR
Chk'd By
Calc. No. 0100F-CA-V0154
Sheet No. 1 of 2
Date 10/9/02
Date 12/12/02
Rev. No. 0

## NOTES

1. OVERBURDEN NODE AREAS ARE APPROXIMATELY 52.79 SQUARE METERS.
2. SAMPLES ARE TAKEN FROM THE APPROXIMATE CENTER OF EACH NODE.
3. THE OVERBURDEN CONSISTS OF SAMPLING AREAS A1, A2, A3 & A4 WITHIN DECISION SUBUNIT 1. SAMPLING AREAS B5, B6, B7, & B8 WITHIN DECISION SUBUNIT 2.

## LEGEND

GAMMA ENERGY ANALYSIS & CLOSEOUT VERIFICATION SAMPLING NODE

GAMMA ENERGY ANALYSIS SAMPLING NODE

## SAMPLE LOCATION TABLE

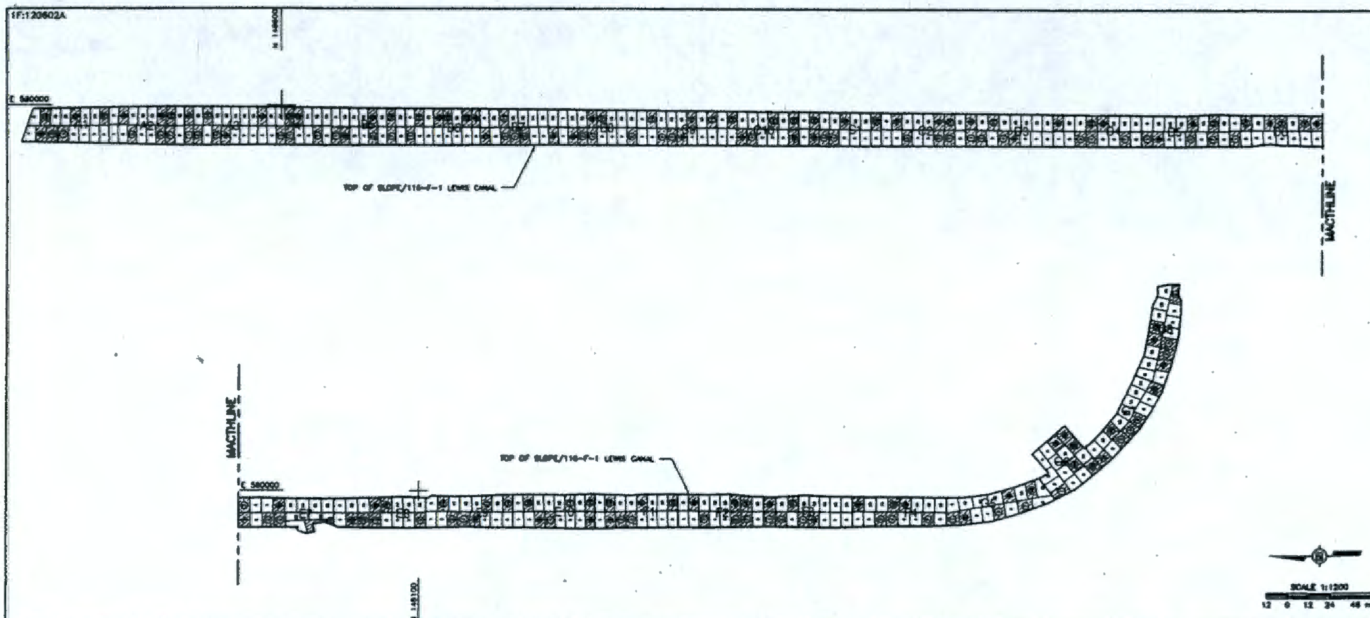
| DECISION SUBUNIT | SAMPLING AREA | SAMPLE NODE | NORTHING | EASTING |
|---|---|---|---|---|
| 1 | A1 | O-A1-2 | 148854.20 | 579886.78 |
| | | O-A1-3 | 148847.87 | 579891.30 |
| | | O-A1-4 | 148841.54 | 579895.83 |
| | | O-A1-10 | 148853.30 | 579886.03 |
| | | O-A1-13 | 148835.02 | 579899.01 |
| | | O-A1-16 | 148819.94 | 579909.74 |
| | A2 | O-A2-2 | 148803.05 | 579920.32 |
| | | O-A2-6 | 148785.09 | 579930.87 |
| | | O-A2-7 | 148772.10 | 579938.40 |
| | | O-A2-10 | 148808.80 | 579908.61 |
| | | O-A2-14 | 148783.44 | 579926.07 |
| | | O-A2-15 | 148778.17 | 579929.16 |
| | A3 | O-A3-1 | 148744.71 | 579952.89 |
| | | O-A3-2 | 148730.55 | 579961.06 |
| | | O-A3-4 | 148726.03 | 579963.72 |
| | | O-A3-5 | 148741.68 | 579951.36 |
| | | O-A3-9 | 148744.58 | 579948.46 |
| | | O-A3-11 | 148753.17 | 579940.58 |
| | A4 | O-A4-3 | 148701.06 | 579993.08 |
| | | O-A4-4 | 148694.74 | 579996.17 |
| | | O-A4-7 | 148675.10 | 579998.83 |
| | | O-A4-8 | 148714.78 | 579976.53 |
| | | O-A4-12 | 148695.62 | 579988.31 |
| | | O-A4-13 | 148688.10 | 579993.53 |
| 2 | B5 | O-B5-1 | 148660.61 | 579993.68 |
| | | O-B5-2 | 148651.73 | 579993.67 |
| | | O-B5-5 | 148632.42 | 579992.28 |
| | | O-B5-7 | 148632.72 | 579998.07 |
| | | O-B5-13 | 148639.08 | 579975.10 |
| | | O-B5-15 | 148626.33 | 579988.27 |
| | B6 | O-B6-1 | 148613.67 | 579985.45 |
| | | O-B6-10 | 148578.18 | 579970.52 |
| | | O-B6-12 | 148573.27 | 579970.82 |
| | | O-B6-13 | 148566.37 | 579965.12 |
| | | O-B6-15 | 148563.63 | 579966.16 |
| | | O-B6-16 | 148563.48 | 579971.06 |
| | B7 | O-B7-1 | 148554.56 | 579966.85 |
| | | O-B7-2 | 148553.63 | 579966.43 |
| | | O-B7-4 | 148553.74 | 579970.28 |
| | | O-B7-5 | 148549.11 | 579963.63 |
| | | O-B7-8 | 148145.87 | 579958.43 |
| | | O-B7-11 | 148138.53 | 579958.06 |
| | B8 | O-B8-2 | 148050.15 | 579953.07 |
| | | O-B8-3 | 148049.78 | 579957.18 |
| | | O-B8-4 | 148049.39 | 579960.97 |
| | | O-B8-8 | 148040.76 | 579958.80 |
| | | O-B8-12 | 147952.53 | 579953.84 |
| | | O-B8-13 | 147943.62 | 579958.87 |

ATTACHMENT 3

U.S DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

100 F AREA
100 AREA REMEDIAL DESIGN
116-F-1 LEWIS CANAL TRENCH
OVERBURDEN SAMPLING PLAN

CN_17ERC.DWG




## NOTES

1. SHALLOW ZONE NODE AREAS ARE APPROXIMATELY 85.38 SQUARE METERS.
2. SAMPLES WILL BE TAKEN FROM THE APPROXIMATE CENTER OF EACH NODE.
3. THE SHALLOW ZONE CONSISTS OF SAMPLING AREAS A1, A2, A3, & A4 WITHIN DECISION SUBUNIT 1, AREAS B5, B6, B7, & B8 WITHIN DECISION SUBUNIT 2, AREAS C9, C10, C1, & C2 WITHIN DECISION SUBUNIT 3, AREAS D3, D4, D5, & D6 WITHIN DECISION SUBUNIT 4, AREAS E7, E8, E9, & E10 WITHIN DECISION SUBUNIT 5, AREAS F1, F2, F3, & F4 WITHIN DECISION SUBUNIT 6, AREAS G5, G6, G7 & G8 WITHIN DECISION SUBUNIT 7.

## LEGEND

- GAMMA ENERGY ANALYSIS/CLOSEOUT VERIFICATION SAMPLING NODE
- GAMMA ENERGY ANALYSIS SAMPLING NODE

## SAMPLE LOCATION TABLE

| DECISION SUBUNIT | SAMPLING AREA | SAMPLE NODE | NORTHING | EASTING |
|---|---|---|---|---|
| 1 | A1 | S-A1-2 | [illegible] | [illegible] |
| | | S-A1-3 | [illegible] | [illegible] |
| | | S-A1-4 | [illegible] | [illegible] |
| | | S-A1-10 | [illegible] | [illegible] |
| | | S-A1-13 | [illegible] | [illegible] |
| | | S-A1-16 | [illegible] | [illegible] |
| | A2 | S-A2-3 | [illegible] | [illegible] |
| | | S-A2-4 | [illegible] | [illegible] |
| | | S-A2-7 | [illegible] | [illegible] |
| | | S-A2-10 | [illegible] | [illegible] |
| | | S-A2-14 | [illegible] | [illegible] |
| | | S-A2-15 | [illegible] | [illegible] |
| | A3 | S-A3-1 | [illegible] | [illegible] |
| | | S-A3-2 | [illegible] | [illegible] |
| | | S-A3-4 | [illegible] | [illegible] |
| | | S-A3-5 | [illegible] | [illegible] |
| | | S-A3-9 | [illegible] | [illegible] |
| | | S-A3-11 | [illegible] | [illegible] |
| | A4 | S-A4-3 | [illegible] | [illegible] |
| | | S-A4-4 | [illegible] | [illegible] |
| | | S-A4-7 | [illegible] | [illegible] |
| | | S-A4-8 | [illegible] | [illegible] |
| | | S-A4-12 | [illegible] | [illegible] |
| | | S-A4-13 | [illegible] | [illegible] |
| 2 | B5 | S-B5-1 | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | S-B5-13 | [illegible] | [illegible] |
| | | S-B5-15 | [illegible] | [illegible] |
| | B6 | [illegible] | [illegible] | [illegible] |
| | | S-B6-10 | [illegible] | [illegible] |
| | | S-B6-12 | [illegible] | [illegible] |
| | | S-B6-13 | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | S-B6-16 | [illegible] | [illegible] |
| | B7 | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | S-B7-11 | [illegible] | [illegible] |
| | B8 | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| 3 | C9 | S-C9-3 | 148582.02 | 579983.87 |
| | | S-C9-4 | 148576.27 | 579982.89 |
| | | S-C9-5 | 148570.53 | 579982.60 |
| | | S-C9-10 | 148598.04 | 579992.41 |
| | | S-C9-14 | 148585.21 | 579993.58 |
| | | S-C9-16 | 148553.82 | 579992.56 |
| | C10 | S-C10-3 | 148536.34 | 579982.90 |
| | | S-C10-4 | 148530.26 | 579982.87 |
| | | S-C10-8 | 148506.83 | 579982.80 |
| | | S-C10-10 | 148517.75 | 579992.51 |
| | | S-C10-14 | 148518.39 | 579992.27 |
| | | S-C10-16 | 148508.81 | 579992.15 |
| | C1 | S-C1-2 | 148495.21 | 579982.80 |
| | | S-C1-3 | 148489.37 | 579982.87 |
| | | S-C1-4 | 148483.47 | 579983.63 |
| | | S-C1-10 | 148482.82 | 579992.58 |
| | | S-C1-13 | 148476.86 | 579992.11 |
| | | S-C1-16 | 148458.28 | 579991.63 |
| | C2 | S-C2-3 | 148441.31 | 579982.84 |
| | | S-C2-4 | 148435.13 | 579982.75 |
| | | S-C2-7 | 148417.00 | 579982.77 |
| | | S-C2-10 | 148447.32 | 579992.03 |
| | | S-C2-14 | 148422.94 | 579991.87 |
| | | S-C2-15 | 148419.88 | 579991.82 |
| 4 | D3 | S-D3-1 | 148404.71 | 579982.95 |
| | | S-D3-2 | 148398.80 | 579983.81 |
| | | S-D3-4 | 148386.96 | 579982.61 |
| | | S-D3-5 | 148380.45 | 579982.77 |
| | | S-D3-9 | 148402.58 | 579981.83 |
| | | S-D3-11 | 148382.03 | 579991.79 |
| | D4 | S-D4-3 | 148342.43 | 579982.74 |
| | | S-D4-4 | 148336.11 | 579982.73 |
| | | S-D4-7 | 148317.00 | 579982.71 |
| | | S-D4-9 | [illegible] | [illegible] |
| | | S-D4-12 | [illegible] | 579991.40 |
| | | S-D4-13 | 148328.87 | 579991.45 |
| | D5 | S-D5-1 | 148304.77 | 579982.32 |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | S-D5-7 | [illegible] | [illegible] |
| | | S-D5-13 | [illegible] | 579991.30 |
| | | S-D5-15 | [illegible] | 579991.78 |
| | D6 | S-D6-1 | [illegible] | [illegible] |
| | | S-D6-10 | [illegible] | [illegible] |
| | | S-D6-12 | [illegible] | [illegible] |
| | | S-D6-13 | [illegible] | [illegible] |
| | | S-D6-15 | [illegible] | [illegible] |
| | | S-D6-16 | [illegible] | 579991.74 |
| 5 | E7 | S-E7-1 | 148196.86 | 579983.38 |
| | | S-E7-3 | [illegible] | [illegible] |
| | | S-E7-4 | 148179.34 | 579983.38 |
| | | S-E7-5 | 148200.01 | 579991.87 |
| | | S-E7-8 | 148180.04 | 579991.85 |
| | | S-E7-11 | 148150.76 | 579983.14 |
| | E8 | S-E8-2 | 148138.17 | 579983.43 |
| | | S-E8-3 | 148131.47 | 579983.39 |
| | | S-E8-4 | 148124.87 | 579983.39 |
| | | S-E8-6 | [illegible] | [illegible] |
| | | S-E8-12 | 148124.81 | 579991.77 |
| | | S-E8-13 | 148118.28 | 579991.80 |
| | E9 | S-E9-3 | 148080.34 | 579983.05 |
| | | S-E9-4 | 148073.81 | 579984.06 |
| | | S-E9-6 | 148067.43 | 579983.83 |
| | | S-E9-10 | [illegible] | [illegible] |
| | | S-E9-14 | 148060.10 | [illegible] |
| | | S-E9-16 | 148046.18 | 579991.63 |
| | E10 | S-E10-3 | 148029.87 | 579983.78 |
| | | S-E10-4 | 148024.02 | 579983.75 |
| | | S-E10-8 | 148001.12 | 579983.75 |
| | | S-E10-10 | 148034.82 | 579993.15 |
| | | S-E10-14 | 148012.76 | 579993.15 |
| | | S-E10-16 | 148001.20 | 579993.32 |
| 6 | F1 | S-F1-2 | 147989.48 | 579983.87 |
| | | S-F1-3 | 147983.53 | 579984.06 |
| | | S-F1-4 | 147977.48 | 579984.12 |
| | | S-F1-10 | [illegible] | [illegible] |
| | | S-F1-13 | 147971.57 | [illegible] |
| | | S-F1-18 | 147953.87 | 579993.70 |
| | F2 | S-F2-3 | [illegible] | [illegible] |
| | | S-F2-6 | 147917.74 | 579984.62 |
| | | S-F2-7 | [illegible] | 579984.63 |
| | | S-F2-10 | [illegible] | [illegible] |
| | | S-F2-14 | [illegible] | 579993.75 |
| | | S-F2-15 | 147911.63 | 579993.40 |
| | F3 | S-F3-1 | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | S-F3-11 | [illegible] | [illegible] |
| | F4 | S-F4-1 | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | S-F4-7 | [illegible] | [illegible] |
| | | [illegible] | [illegible] | [illegible] |
| | | S-F4-12 | [illegible] | [illegible] |
| | | S-F4-13 | [illegible] | [illegible] |
| 7 | G5 | S-G5-1 | 147782.69 | 579984.74 |
| | | S-G5-2 | [illegible] | [illegible] |
| | | S-G5-6 | [illegible] | [illegible] |
| | | S-G5-7 | [illegible] | [illegible] |
| | | S-G5-13 | [illegible] | [illegible] |
| | | S-G5-16 | 147746.31 | 580001.30 |
| | G6 | S-G6-1 | [illegible] | [illegible] |
| | | S-G6-10 | 147734.01 | 580016.07 |
| | | S-G6-12 | [illegible] | [illegible] |
| | | S-G6-13 | [illegible] | [illegible] |
| | | S-G6-15 | [illegible] | [illegible] |
| | | S-G6-16 | 147728.74 | 580032.79 |
| | G7 | S-G7-1 | [illegible] | 580019.44 |
| | | S-G7-3 | [illegible] | [illegible] |
| | | S-G7-4 | [illegible] | [illegible] |
| | | S-G7-6 | [illegible] | 580041.57 |
| | | S-G7-8 | [illegible] | [illegible] |
| | | S-G7-11 | [illegible] | [illegible] |
| | G8 | S-G8-2 | [illegible] | [illegible] |
| | | S-G8-3 | [illegible] | [illegible] |
| | | S-G8-5 | [illegible] | [illegible] |
| | | S-G8-8 | [illegible] | [illegible] |
| | | S-G8-12 | [illegible] | [illegible] |
| | | S-G8-13 | 147677.43 | [illegible] |

U.S DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

100 F AREA
116-F-1 LEWIS CANAL TRENCH
SHALLOW ZONE SAMPLING PLAN

# CALCULATION COVER SHEET

| | | | |
|---|---|---|---|
| **Project Title:** | 116-F-1 Cleanup Verification | **Job No.** | 22192 |
| **Area** | 100 F | | |
| **Discipline** | Environmental | **Calc. No.** | 0100F-CA-V0138 |
| **Subject** | 116-F-1 Lewis Canal Cleanup Verification 95% UCL Calculation | | |
| **Computer Program** | Excel | **Program No.** | Excel 97 |

Use of this calculation by persons who do not have access to all of the pertinent facts could lead to incorrect conclusions or assumptions. Before applying this calculation in your work, this calculation must be thoroughly reviewed with appropriate and authorized Hanford site ERC personnel. Without this review, the ERC cannot assume any responsibility for the use of these calculations.

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

| Rev. | Sheet Numbers | Originator | Checker | Reviewer | Approval | Date |
|---|---|---|---|---|---|---|
| 0 | Cover = 1<br>Sheets = 6<br>Total = 7 | J.E. Thomson 3/24/03<br>J. E. Thomson | SW Callison 3-25-03<br>S. W. Callison<br>JB Miley 3-25-03<br>T.B. Miley | KE Cook 3/26/03<br>K.E. Cook | 3/26/03<br>M.A. Buckmaster | 3/26/03 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**SUMMARY OF REVISIONS**

| | |
|---|---|
| | |
| | |

*Obtain Calc. No. from DIS

Dec-02

DE01-437.03

**Bechtel Hanford, Inc.** CALCULATION SHEET

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Originator | J. E. Thomson | Date | 3/24/03 | Calc. No. | 0100F-CA-V0138 | Rev. No. | 0 |
| Project | 116-F-1 Cleanup Verification | Job No. | 22192 | Checked | S. W. Callison SWC | Date | 3-25-03 |
| | | | | | T.B. Miley TBM | | 3-25-03 |
| Subject | 116-F-1 Lewis Canal Cleanup Verification 95% UCL Calculation | | | | | Sheet No. | 1 of 6 |

**Purpose:**
Calculate the 95% UCL to evaluate compliance with cleanup standards for the 116-F-1 Lewis Canal. Also, calculate the carcinogenic risk for applicable nonradionuclide analytes (shallow zone only), WAC 173-340 (Model Toxics Control Act) 3-part test, if required (all nonradionuclide analytes), and the relative percent difference (RPD) for each contaminant of concern (COC).

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**Given/References:**
1) Sample Results
2) Lookup values from Remedial Design Report/Remedial Action Work Plan (RDR/RAWP) (DOE-RL 2001). All lookup values and RAGs are taken from RDR/RAWP unless otherwise specified.
3) DOE-RL, 2001, 100 Area Remedial Action Sampling and Analysis Plan (SAP), DOE/RL-96-22, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
4) DOE-RL, 2002, Remedial Design Report/Remedial Action Work Plan for the 100 Area, DOE/RL-96-17, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
5) BHI, 1999, Instruction Guide for the Remediation of the 100-BC-1, 100-DR-1, and 100-HR-1 Waste Sites, 0100X-IG-G0001, Rev. 3, Bechtel Hanford, Inc., Richland, Washington.
6) Model Toxics Control Act, Washington Administrative Code-173-340, and Statistical Guidance for Ecology Site Managers, Ecology Pub. #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).
8) EPA, 1994, WSEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, EPA 540/R-94/013.
9) Ecology, 1996 Model Toxic Control Act Cleanup Levels and Risk Calculations (CLARC III) Update, Publication #940145, Washington State Department of Ecology, Olympia, Washington.

**Solution:**
Calculation methodology is described in Ecology Pub. #92-54 and below. Use data from attached worksheets to calculate the 95% upper confidence limit (UCL) for each analyte and carcinogenic risk and to perform the WAC 173-340 3-part test for nonradionuclides and RPD calculations for each COC.

**Calculation Description:**
The subject calculations were performed on data from soil verification samples from waste site 116-F-1 Lewis Canal. The data were entered into an EXCEL 97 spreadsheet and calculations performed by utilizing 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 is documented by this calculation. Split and duplicate RPD results are used in evaluation of data quality and are presented in the Cleanup Verfication Package (CVP) for this site.

**Methodology:**
The statistical value calculated to evaluate the effectiveness of cleanup was the 95% UCL. For nonradioactive analytes with > 50% of the data below detection limits, the maximum value for the sample data was used instead of the 95% UCL. All nonradionuclide (e.g., metals) data reported as being below detection limits were 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 minimal 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. For nonradionuclide small data sets (n < 10) and all radionuclide data sets, the calculations are performed assuming nonparametric distribution, and no test for distribution is performed. For nonradionuclide large data sets (n >= 10), a distribution test is conducted on the data set using Ecology MTCAStat software.

The estimated hazard quotient (for applicable nonradionuclide COCs) is determined by dividing the statistical value (derived in this calculation) by the WAC 173-340 B non-carcinogenic cleanup limit. The nonradionuclide carcinogenic risk, above background, is determined by dividing the statistical value by the WAC 173-340 B carcinogenic cleanup limit and then multiplying by $10^{-6}$. For data sets where all values are below detection, neither of these calculations are required. For noncarcinogenic nonradionuclide COCs, only the estimated fraction of risk computation must be performed.

The WAC 173-340 3-part test determines if:
1) the statistical value exceeds the most stringent cleanup limit for each non-radionuclide COC,
2) greater than 10% of the raw data exceed the most stringent cleanup limit for each non-radionuclide COC,
3) the maximum value of the raw data set exceeds two times the most stringent cleanup limit for each non-radionuclide COC.

The 3-part test is performed for nonradionuclide analytes found in overburden, the shallow zone, and the deep zone (as necessary).

The RPD is performed when both the main value and, either the duplicate or split values 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. These detection limit requirements are located in Table II-2 of the SAP, DOE/RL-96-22, where they are referred to as the RDL. 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 QA/QC split and duplicate RPD calculations, a value less than +/- 30% indicates the data compare favorably. If the RPD is greater than +/- 30%, further investigation regarding the usability of the data is performed. Additional discussion as necessary is provided in the data quality assessment section of the applicable CVP.

Bechtel Hanford, Inc.

**CALCULATION SHEET**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Originator | J. E. Thomson | Date | 3/24/03 | Calc. No. | 0100F-CA-V0138 | Rev. No. | 0 |
| Project | 116-F-1 Cleanup Verification | Job No. | 22192 | Checked | S. W. Callison SWC | Date | 3-25-03 |
| | | | | | T.B. Miley TBM | | 3-25-03 |
| Subject | 116-F-1 Lewis Canal Cleanup Verification 95% UCL Calculation | | | | | Sheet No. | 2 of 6 |

**Results:**

The results presented in the summary tables that follow are for use in RESRAD dose/risk analysis and the Cleanup Verification Package (CVP) for this site.

| Result Summary - Shallow Zone | | | Result Summary- Overburden | | |
|---|---|---|---|---|---|
| As | 6.0E+00 | mg/kg | As | 1.1E+01 | mg/kg |
| Cr+6a | 1.5E+00 | mg/kg | Cr+6 | 4.3E-01 U | mg/kg |
| C-14 | 1.47E+00 | pCi/g | C-14 | 6.33E-01 U | pCi/g |
| Cs-137 | 1.10E-01 | pCi/g | Cs-137 | 0 (< BG) U | pCi/g |
| Co-60 | 5.49E-02 U | pCi/g | Co-60 | 1.62E-02 U | pCi/g |
| Eu-152 | 1.77E-01 | pCi/g | Eu-152 | 5.24E-02 U | pCi/g |
| Eu-154 | 1.37E-01 U | pCi/g | Eu-154 | 4.91E-02 U | pCi/g |

| WAC 173-340 Evaluation (Shallow Zone) | | | WAC 173-340 Evaluation (Overburden) | | |
|---|---|---|---|---|---|
| **WAC 173-340 3-Part Test:** | | | **WAC 173-340 3-Part Test:** | | |
| 95% UCL > Cleanup Limit? | NO | | 95% UCL > Cleanup Limit? | NO | |
| > 10% above Cleanup Limit? | NO | | > 10% above Cleanup Limit? | NO | |
| Any sample > 2X Cleanup Limit? | NO | | Any sample > 2X Cleanup Limit? | NO | |
| **Risk Estimate:** | | | **Risk Estimate:** | | |
| Nonrad noncarcinogenic sum of quotients: | | 3.75E-03 | Nonrad noncarcinogenic sum of quotients: | | 1.08E-03 |
| Nonrad carcinogenic risk: | | 7E-07 | Nonrad carcinogenic risk: | | 2E-07 |

**Split/Duplicate Results:**

**Relative Percent Difference (RPD) Results***

| QA/QC Analysis Shallow Zone | | | QA/QC Analysis Shallow Zone | | |
|---|---|---|---|---|---|
| Analyte | Duplicate Analysis J00FF9/J00FH0 | Split Analysis J00FF9/J00FK9 | Analyte | Duplicate Analysis J00FJ4/J00FJ5 | Split Analysis J00FJ4/J00FLC |
| As | 31% | 9.5% | As | 25% | 20% |
| Cr+6 | | | Cr+6 | | |
| C-14 | | | C-14 | | |
| Cs-137 | | | Cs-137 | | |
| Co-60 | | | Co-60 | | |
| Eu-152 | | | Eu-152 | | |
| Eu-154 | | | Eu-154 | | |

**QA/QC Analysis**

| Overburden Split/Dup | | |
|---|---|---|
| Analyte | Duplicate Analysis | Split Analysis |
| As | 5.9% | 20.0% |
| Cr+6 | | |
| C-14 | | |
| Cs-137 | | |
| Co-60 | | |
| Eu-152 | | |
| Eu-154 | | |

* A blank box indicates the RPD did not need to be calculated. RPD calculation is required when both samples are greater than the MDA and both samples are greater than 5 times the TDL.

Bechtel Hanford, Inc.

CALCULATION SHEET

Originator: J. E. Thomson
Project: 116-F-1 Cleanup Verification
Subject: 116-F-1 Lewis Canal Cleanup Verification 95% UCL Calculation

Date: 3/24/03
Job No.: 22192

Calc. No.: 5100F-CA-V0139
Checked by: S. W. Callison SWC 3-25-03
T.B. Miley TBM 3-25-03

Rev. No.: 0
Date
Sheet No.: 3 of 6

116-F-1 Shallow Zone Data

| Sampling Area | HEIS Number | Sample Date | As pCi/g | As Q | As MDA | Cr+6* pCi/g | Cr+6* Q | Cr+6* MDA | C-14 pCi/g | C-14 Q | C-14 MDA | Cs-137 pCi/g | Cs-137 Q | Cs-137 MDA | Co-60 pCi/g | Co-60 Q | Co-60 MDA | Eu-152 pCi/g | Eu-152 Q | Eu-152 MDA | Eu-154 pCi/g | Eu-154 Q | Eu-154 MDA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SA1 | J00FF9 | 1/07/2003 | 3.0E+00 | | 4.0E-01 | 4.30E-01 | U | 4.30E-01 | 2.79E-01 | U | 3.40E+00 | 1.36E-01 | | 8.90E-02 | 8.80E-02 | U | 8.80E-02 | 1.90E-01 | U | 1.90E-01 | 2.20E-01 | U | 2.20E-01 |
| Duplicate of J00FF9 | J00FH0 | 1/07/2003 | 4.1E+00 | | 4.0E-01 | 4.3E-01 | U | 4.3E-01 | -1.08E+00 | U | 3.70E+00 | 1.57E-01 | | 8.60E-02 | 9.80E-02 | U | 9.80E-02 | 2.00E-01 | U | 2.00E-01 | 2.80E-01 | U | 2.90E-01 |
| SD5 | J00FJ4 | 1/8/2003 | 7.7E+00 | | 2.1E-01 | 4.3E-01 | U | 4.3E-01 | 2.04E+00 | U | 3.70E+00 | 4.30E-02 | | 4.30E-02 | 4.20E-02 | U | 4.20E-02 | 1.60E-01 | U | 1.00E-01 | 1.30E-01 | U | 1.30E-01 |
| Duplicate of J00FJ4 | J00FJ5 | 1/8/2003 | 6.0E+00 | | 3.3E-01 | 4.8E-01 | U | 4.8E-01 | 2.81E+00 | | 3.40E+00 | 1.30E-01 | | 1.10E-01 | 1.00E-01 | U | 1.00E-01 | 2.30E-01 | U | 2.30E-01 | 2.90E-01 | U | 2.90E-01 |
| SA2 | J00FH1 | 1/07/2003 | 4.3E+00 | | 3.5E-01 | 4.4E-01 | U | 4.4E-01 | 8.10E-01 | U | 3.60E+00 | 1.07E-01 | U | 1.10E-01 | 1.10E-01 | U | 1.10E-01 | 2.80E-01 | U | 2.50E-01 | 2.90E-01 | U | 2.90E-01 |
| SA3 | J00FH2/J00HL6[a] | 1/7/2003, 3/26/03 | 3.7E+00 | | 4.3E-01 | 4.3E-01 | U | 4.3E-01 | 3.02E-01 | U | 2.80E+00 | 1.00E-01 | U | 1.00E-01 | 1.30E-01 | U | 1.30E-01 | 2.50E-01 | U | 2.50E-01 | 3.10E-01 | U | 3.10E-01 |
| SA4 | J00FH3/J00HL5[a] | 1/7/2003, 3/26/03 | 1.7E+00 | | 3.9E-01 | 4.2E-01 | U | 4.2E-01 | 5.09E-01 | U | 3.80E+00 | 5.00E-02 | U | 5.00E-02 | 8.60E-02 | U | 8.60E-02 | 1.40E-01 | U | 1.40E-01 | 2.10E-01 | U | 2.10E-01 |
| SB5 | J00FH4 | 1/07/2003 | 1.9E+00 | | 3.8E-01 | 4.2E-01 | | 4.2E-01 | -2.08E-01 | U | 3.10E+00 | 8.50E-02 | U | 8.50E-02 | 1.00E-01 | U | 1.00E-01 | 1.90E-01 | U | 1.90E-01 | 2.80E-01 | U | 2.80E-01 |
| SB6 | J00FH5/J00HL6[a] | 1/7/2003, 3/26/03 | 4.1E+00 | | 4.1E-01 | 4.1E-01 | U | 4.1E-01 | -8.80E-02 | U | 3.30E+00 | 1.63E-01 | | 9.40E-02 | 2.70E-01 | U | 2.70E-01 | 6.10E-01 | | 2.40E-01 | 2.50E-01 | U | 2.50E-01 |
| SB7 | J00FH6 | 1/07/2003 | 2.4E+00 | | 4.0E-01 | 1.3E+00 | | 4.2E-01 | 6.65E-01 | U | 3.10E+00 | 7.40E-02 | U | 7.40E-02 | 3.70E-02 | U | 3.70E-02 | 1.20E-01 | U | 1.20E-01 | 1.70E-01 | U | 1.70E-01 |
| SB8 | J00FH7 | 1/7/2003 | 3.6E+00 | | 3.8E-01 | 6.3E-01 | | 4.3E-01 | 4.33E-01 | U | 3.10E+00 | 7.70E-02 | U | 7.70E-02 | 6.30E-02 | U | 6.30E-02 | 1.40E-01 | U | 1.40E-01 | 2.10E-01 | U | 2.10E-01 |
| SC9 | J00FH8 | 1/7/2003 | 7.3E+00 | | 3.8E-01 | 1.5E+00 | | 4.4E-01 | 4.84E-01 | U | 3.20E+00 | 1.30E-01 | U | 1.30E-01 | 1.20E-01 | U | 1.20E-01 | 2.90E-01 | U | 2.90E-01 | 3.90E-01 | U | 3.90E-01 |
| SC10 | J00FH9 | 1/7/2003 | 6.3E+00 | | 3.5E-01 | 4.8E-01 | U | 4.5E-01 | 1.54E+00 | U | 2.90E+00 | 7.30E-02 | U | 7.30E-02 | 7.20E-02 | U | 7.20E-02 | 1.60E-01 | U | 1.80E-01 | 2.50E-01 | U | 2.50E-01 |
| SC1 | J00FJ0 | 1/7/2003 | 1.3E+01 | | 4.2E-01 | 4.6E-01 | U | 4.6E-01 | 2.32E+00 | U | 2.70E+00 | 1.00E-01 | U | 1.00E-01 | 1.10E-01 | U | 1.10E-01 | 2.70E-01 | U | 2.70E-01 | 2.90E-01 | U | 2.90E-01 |
| SC2 | J00FJ1 | 1/7/2003 | 5.7E+00 | | 3.8E-01 | 4.2E-01 | U | 4.2E-01 | 2.10E+00 | U | 2.80E+00 | 9.80E-02 | U | 9.80E-02 | 1.00E-01 | U | 1.00E-01 | 2.30E-01 | U | 2.30E-01 | 2.90E-01 | U | 2.90E-01 |
| SD3 | J00FJ2 | 1/7/2003 | 3.9E+00 | | 3.7E-01 | 1.2E+00 | | 4.6E-01 | 2.05E+00 | U | 2.80E+00 | 6.80E-02 | U | 6.80E-02 | 7.70E-02 | U | 7.70E-02 | 1.60E-01 | U | 1.60E-01 | 2.30E-01 | U | 2.30E-01 |
| SD4 | J00FJ3 | 1/7/2003 | 6.6E+00 | | 4.2E-01 | 4.5E-01 | U | 4.5E-01 | 2.30E-01 | U | 2.30E+00 | 1.66E-01 | U | 8.90E-02 | 6.70E-02 | U | 6.70E-02 | 1.30E-01 | U | 2.30E-01 | 2.80E-01 | U | 2.80E-01 |
| SD6 | J00FJ6 | 1/8/2003 | 6.5E+00 | | 4.3E-01 | 1.3E+00 | | 4.6E-01 | 2.37E+00 | U | 2.40E+00 | 2.43E-01 | | 3.90E-02 | 7.80E-02 | U | 7.80E-02 | 3.61E-01 | | 6.50E-02 | 1.09E-01 | U | 1.09E-01 |
| SE7 | J00FJ7 | 1/8/2003 | 4.0E+00 | | 4.2E-01 | 4.6E-01 | U | 4.6E-01 | 1.38E+00 | U | 3.50E+00 | 3.00E-02 | U | 3.00E-02 | 3.20E-02 | U | 3.20E-02 | 7.50E-02 | U | 7.50E-02 | 1.10E-01 | U | 1.10E-01 |
| SE8 | J00FJ8 | 1/8/2003 | 6.7E+00 | | 4.1E-01 | 4.6E-01 | U | 4.6E-01 | 1.44E+00 | U | 2.20E+00 | 5.60E-02 | U | 5.60E-02 | 3.50E-02 | U | 3.50E-02 | 8.20E-02 | U | 8.20E-02 | 1.10E-01 | U | 1.10E-01 |
| SE9 | J00FJ9/J00HL7[a] | 1/7/2003, 3/26/03 | 2.8E+00 | | 3.9E-01 | 4.5E-01 | | 4.5E-01 | 1.09E+00 | U | 2.60E+00 | 1.74E-01 | | 1.20E-01 | 1.20E-01 | U | 1.20E-01 | 2.31E-01 | U | 2.50E-01 | 3.50E-01 | U | 3.60E-01 |
| SE10 | J00FK0 | 1/8/2003 | 1.6E+01 | | 3.8E-01 | 4.4E-01 | U | 4.4E-01 | 1.47E+00 | U | 2.60E+00 | 7.10E-02 | U | 7.10E-02 | 7.40E-02 | U | 7.40E-02 | 1.70E-01 | U | 1.70E-01 | 2.30E-01 | U | 2.30E-01 |
| SF1 | J00FK1 | 1/8/2003 | 3.8E+00 | | 3.9E-01 | 4.7E-01 | U | 4.7E-01 | 1.97E+00 | U | 3.60E+00 | 9.00E-02 | U | 9.00E-02 | 1.90E-01 | U | 1.90E-01 | 2.40E-01 | U | 2.40E-01 | 3.20E-01 | U | 3.20E-01 |
| SF2 | J00FK2 | 1/8/2003 | 2.3E+00 | | 3.8E-01 | 4.2E-01 | U | 4.2E-01 | 1.02E+00 | U | 2.50E+00 | 9.20E-02 | U | 9.20E-02 | 1.10E-01 | U | 1.10E-01 | 2.20E-01 | U | 2.20E-01 | 2.70E-01 | U | 2.70E-01 |
| SF3 | J00FK3 | 1/8/2003 | 3.7E+00 | | 4.2E-01 | 4.6E-01 | | 4.5E-01 | 1.55E+00 | U | 2.40E+00 | 9.00E-02 | U | 9.00E-02 | 9.60E-02 | U | 9.60E-02 | 2.20E-01 | U | 2.20E-01 | 2.90E-01 | U | 2.90E-01 |
| SF4 | J00FK4 | 1/8/2003 | 3.2E+00 | | 4.0E-01 | 4.4E-01 | | 4.2E-01 | 1.04E+00 | U | 2.30E+00 | 1.80E-01 | U | 1.80E-01 | 1.10E-01 | U | 1.10E-01 | 2.40E-01 | U | 2.60E-01 | 3.30E-01 | U | 3.30E-01 |
| SG5 | J00FK5 | 1/8/2003 | 6.1E+00 | | 4.3E-01 | 4.4E-01 | U | 4.4E-01 | 1.81E+00 | U | 2.80E+00 | 9.30E-02 | U | 9.30E-02 | 9.40E-02 | U | 9.40E-02 | 2.00E-01 | U | 2.00E-01 | 2.70E-01 | U | 2.70E-01 |
| SG6 | J00FK6 | 1/8/2003 | 3.5E+00 | | 3.7E-01 | 4.4E-01 | U | 4.4E-01 | 1.91E+00 | U | 2.50E+00 | 7.30E-02 | U | 7.30E-02 | 7.60E-02 | U | 7.60E-02 | 1.60E-01 | U | 1.60E-01 | 2.30E-01 | U | 2.30E-01 |
| SG7 | J00FK7 | 1/8/2003 | 2.3E+00 | | 4.1E-01 | 4.3E-01 | U | 4.3E-01 | 1.94E+00 | U | 2.10E+00 | 1.00E-01 | U | 1.00E-01 | 7.60E-02 | U | 7.60E-02 | 2.30E-01 | U | 2.30E-01 | 3.50E-01 | U | 3.50E-01 |
| SG8 | J00FK8 | 1/8/2003 | 2.1E+00 | | 3.6E-01 | 4.3E-01 | U | 4.3E-01 | 2.14E+00 | | 2.10E+00 | 5.50E-02 | U | 5.50E-02 | 6.20E-02 | U | 6.20E-02 | 1.30E-01 | U | 1.30E-01 | 1.90E-01 | U | 1.90E-01 |

a These areas were resampled on the indicated dates following additional remediation, and reanalyzed for the indicated COCs

Statistical Computation Input Data

| Composite Point | HEIS Number | Sample Date | As pCi/g | Cr+6a pCi/g | C-14 pCi/g | Cs-137 pCi/g | Co-60 pCi/g | Eu-152 pCi/g | Eu-154 pCi/g |
|---|---|---|---|---|---|---|---|---|---|
| SA1 | J00FF9/J00FH0 | 1/07/2003 | 3.6E+00 | 2.2E-01 | -4.08E-01 | 1.48E-01 | 4.83E-02 | 9.75E-02 | 1.28E-01 |
| SD5 | J00FJ4/J00FJ5 | 1/08/2003 | 6.8E+00 | 2.3E-01 | 2.46E+00 | 9.85E-02 | 3.56E-02 | 8.25E-02 | 1.05E-01 |
| SA2 | J00FH1 | 1/07/2003 | 4.3E+00 | 2.2E-01 | 8.10E-01 | 1.07E-01 | 5.50E-02 | 1.25E-01 | 1.45E-01 |
| SA3 | J00FH2/J00HL6a | 1/7/2003, 3/26/03* | 3.7E+00 | 2.1E-01 | 3.02E-01 | 1.00E-01 | 6.50E-02 | 1.25E-01 | 1.55E-01 |
| SA4 | J00FH3/J00HL5a | 1/7/2003, 3/26/03* | 1.7E+00 | 2.1E-01 | 5.09E-01 | 5.00E-02 | 3.30E-02 | 7.00E-02 | 1.05E-01 |
| SB5 | J00FH4 | 1/07/2003 | 1.9E+00 | 4.2E-01 | -2.08E-01 | 8.50E-02 | 5.00E-02 | 9.50E-02 | 1.40E-01 |
| SB6 | J00FH5/J00HL6a | 1/7/2003, 3/26/03* | 4.1E+00 | 2.1E-01 | -8.80E-02 | 1.63E-01 | 1.35E-01 | 6.10E-01 | 1.25E-01 |
| SB7 | J00FH6 | 1/07/2003 | 2.4E+00 | 1.3E+00 | 6.65E-01 | 7.40E-02 | 2.85E-02 | 6.00E-02 | 8.50E-02 |
| SB8 | J00FH7 | 1/7/2003 | 3.6E+00 | 6.3E-01 | 4.33E-01 | 7.70E-02 | 3.15E-02 | 7.00E-02 | 1.00E-01 |
| SC9 | J00FH8 | 1/7/2003 | 7.3E+00 | 1.5E+00 | 4.84E-01 | 1.30E-01 | 6.00E-02 | 1.45E-01 | 1.95E-01 |
| SC10 | J00FH9 | 1/7/2003 | 6.3E+00 | 2.3E-01 | 1.54E+00 | 7.30E-02 | 3.60E-02 | 9.00E-02 | 1.25E-01 |
| SC1 | J00FJ0 | 1/7/2003 | 1.3E+01 | 2.3E-01 | 2.32E+00 | 1.00E-01 | 5.50E-02 | 1.35E-01 | 1.45E-01 |
| SC2 | J00FJ1 | 1/7/2003 | 5.7E+00 | 2.1E-01 | 2.10E+00 | 9.80E-02 | 5.00E-02 | 1.15E-01 | 1.45E-01 |
| SD3 | J00FJ2 | 1/7/2003 | 3.9E+00 | 1.2E+00 | 2.05E+00 | 6.80E-02 | 3.85E-02 | 8.00E-02 | 1.15E-01 |
| SD4 | J00FJ3 | 1/7/2003 | 6.6E+00 | 2.3E-01 | 8.30E-01 | 8.00E-02 | 4.35E-02 | 1.15E-01 | 1.40E-01 |
| SD6 | J00FJ6 | 1/8/2003 | 6.5E+00 | 1.2E+00 | 2.37E+00 | 2.43E-01 | 3.90E-02 | 5.61E-01 | 5.00E-02 |
| SE7 | J00FJ7 | 1/8/2003 | 4.0E+00 | 1.3E+00 | 1.38E+00 | 3.00E-02 | 3.20E-02 | 3.75E-02 | 5.50E-02 |
| SE8 | J00FJ8 | 1/8/2003 | 5.7E+00 | 2.3E-01 | 1.44E+00 | 5.60E-02 | 3.50E-02 | 5.50E-02 | 5.90E-02 |
| SE9 | J00FJ9/J00HL7a | 1/7/2003, 3/26/03* | 2.8E+00 | 4.5E-01 | 1.09E+00 | 1.74E-01 | 1.20E-01 | 2.31E-01 | 1.75E-01 |
| SE10 | J00FK0 | 1/8/2003 | 1.6E+01 | 2.2E-01 | 1.47E+00 | 7.10E-02 | 3.70E-02 | 8.50E-02 | 1.15E-01 |
| SF1 | J00FK1 | 1/8/2003 | 3.8E+00 | 2.4E-01 | 1.97E+00 | 9.00E-02 | 9.50E-02 | 1.20E-01 | 1.60E-01 |
| SF2 | J00FK2 | 1/8/2003 | 2.3E+00 | 2.1E-01 | 1.02E+00 | 9.20E-02 | 5.50E-02 | 1.10E-01 | 1.35E-01 |
| SF3 | J00FK3 | 1/8/2003 | 3.7E+00 | 4.6E-01 | 1.55E+00 | 9.00E-02 | 4.80E-02 | 1.10E-01 | 1.45E-01 |
| SF4 | J00FK4 | 1/8/2003 | 3.2E+00 | 8.4E-01 | 1.04E+00 | 1.80E-01 | 5.50E-02 | 1.30E-01 | 1.65E-01 |
| SG5 | J00FK5 | 1/8/2003 | 6.1E+00 | 2.2E-01 | 1.81E+00 | 9.30E-02 | 4.70E-02 | 1.00E-01 | 1.35E-01 |
| SG6 | J00FK6 | 1/8/2003 | 3.5E+00 | 2.2E-01 | 1.91E+00 | 7.30E-02 | 3.50E-02 | 8.00E-02 | 1.15E-01 |
| SG7 | J00FK7 | 1/8/2003 | 2.3E+00 | 2.2E-01 | 1.08E+00 | 1.00E-01 | 3.80E-02 | 1.10E-01 | 1.75E-01 |
| SG8 | J00FK8 | 1/8/2003 | 2.1E+00 | 2.2E-01 | 2.14E+00 | 5.50E-02 | 3.10E-02 | 9.50E-02 | 9.50E-02 |

Statistical Computations

| | As | Cr+6a | C-14 | Cs-137 | Co-60 | Eu-152 | Eu-154 |
|---|---|---|---|---|---|---|---|
| Statistical value based on | Large data set. Lognormal distribution. Statistic calculated using Land's method. | >50% Below Detection. Default to Maximum Value | Radionuclide data set. Use nonparametric z-stat | Radionuclide data set. Use nonparametric z-stat | Radionuclide data set. Use nonparametric z-stat | Radionuclide data set. Use nonparametric z-stat | Radionuclide data set. Use nonparametric z-stat |
| N | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| % < Detection limit | 0% | 58% | 93% | 82% | 100% | 93% | 100% |
| mean | 4.9E+00 | 4.3E-01 | 1.22E+00 | 9.70E-02 | 4.77E-02 | 1.38E-01 | 1.28E-01 |
| st. dev. | 3.3E+00 | 3.9E-01 | 8.07E-01 | 4.29E-02 | 2.32E-02 | 1.33E-01 | 3.61E-02 |
| z-statistic | 1.645 | 1.645 | 1.645 | 1.645 | 1.645 | 1.645 | 1.645 |
| 95%UCL on mean | 6.0E+00 * | 5.8E-01 | 1.47E+00 | 1.10E-01 | 5.49E-02 | 1.77E-01 | 1.37E-01 |
| max value | 1.6E+01 | 1.5E+00 | 2.9E+00 | 2.4E-01 | 2.7E-01 U | 6.2E-01 | 3.9E-01 U |
| Statistical value | 6.0E+00 * | 1.5E+00 | 1.47E+00 | 1.10E-01 | 5.49E-02 | 1.77E-01 | 1.37E-01 |
| Background | NA | NA | NA | NA | NA | NA | NA |
| Statistical value above background | 6.0E+00 * | 1.5E+00 | 1.47E+00 | 1.10E-01 | 5.49E-02 | 1.77E-01 | 1.37E-01 |
| Lookup Value - 15 mrem/yr for ra | | | 5.16 | 6.2 | 1.4 | 3.3 | 3.0 |
| Most Stringent Cleanup Limit for nonradionuclide and RAG Type | 20 River Protection, Hanford Site Background | 2 River Protection | | | | | |

| | | |
|---|---|---|
| WAC 173-340 3-PART TEST | | |
| 95% UCL > Cleanup Limit | NO | NO |
| > 10% above Cleanup Limit | NO | NO |
| Any sample > 2X Cleanup Limit | NO | NO |
| EXCESS RISK EVALUATION | | |
| WAC 173-340 B Non-Carcinogenic Cleanup | 24 | 400 |
| Hazard quotient for each nonradionuclide | NA | 3.9E-03 |
| WAC 173-340 B Carcinogenic Cleanup | 0.87 | 2.1 |
| Excess risk for each carcinogenic nonradionuclide | NA | 7.1E-07 |
| NON-RAD SUMMARY | | |
| WAC 173-340 3-Part-Test Compliance: | YES | Because statistical value for arsenic is below Hanford Site background, the hazard quotient and excess risk are not calculated. |
| Nonrad noncarcinogenic sum of quotients: | 3.9E-03 | |
| Nonrad carcinogenic risk: | 7E-07 | |

* Statistical value based on MTCAStat calculation using Land's method and assuming lognormal distribution.

**Bechtel Hanford, Inc.** **CALCULATION SHEET**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Originator** | J. E. Thomson | **Date** | 3/24/03 | **Calc. No.** | 0100F-CA-V0138 | **Rev. No.** | 0 |
| **Project** | 116-F-1 Cleanup Verification | **Job No.** | 22192 | **Checked** | S. W. Callison | **Date** | 3-25-03 |
| | | | | | T.B. Miley | | 3-25-03 |
| **Subject** | 116-F-1 Lewis Canal Cleanup Verification 95% UCL Calculation | | | | | **Sheet No.** | 4 of 6 |

Shallow zone arsenic MTCAStat UCL Calculation

| | | | |
|---|---|---|---|
| Number of samples | | Uncensored values | |
| Uncensored | 28 | Mean | 4.9 |
| Censored | | Lognormal mean | 4.9 |
| Detection limit or PQL | | Std. devn. | 3.2 |
| Method detection limit | | Median | 4.0 |
| TOTAL | 28 | Min. | 1.7 |
| | | Max. | 16 |

| | | | |
|---|---|---|---|
| Lognormal distribution? | | Normal distribution? | |
| r-squared is: | 0.956 | r-squared is: | 0.748 |

Recommendations:
Use lognormal distribution.

UCL (Land's method) is 6.0

Bechtel Hanford, Inc.

**CALCULATION SHEET**

| | | | | | |
|---|---|---|---|---|---|
| Originator | J. E. Thomson | Date: | 3/24/03 | Calc. No. | 0100F0CA-V0136 |
| Project | 116-F-1 Cleanup Verification | Job No. | 22192 | Checked by: | S. W. Callison / T.B. Miley |
| Subject | 116-F-1 Cleanup Verification 95% UCL Calculation | | | | |

Rev. No.: 0
Date: 3-25-03 / 3-25-03
Sheet No.: 5 of 6

**116-F-1 Overburden Data**

| Sample Area | HEIS Number | Sample Date | As pCi/g | As Q | As MDA | Cr+6 pCi/g | Cr+6 Q | Cr+6 MDA | C-14 pCi/g | C-14 Q | C-14 MDA | Cs-137 pCi/g | Cs-137 Q | Cs-137 MDA | Co-60 pCi/g | Co-60 Q | Co-60 MDA | Eu-152 pCi/g | Eu-152 Q | Eu-152 MDA | Eu-154 pCi/g | Eu-154 Q | Eu-154 MDA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OA1 | J00C01 | 12/11/2002 | 3.3E+00 | | 4.0E-01 | 4.3E-01 | U | 4.3E-01 | -7.57E-01 | U | 2.00E+00 | 4.40E-02 | U | 4.40E-02 | 4.70E-02 | U | 4.70E-02 | 1.10E-01 | U | 1.10E-01 | 1.70E-01 | U | 1.70E-01 |
| Duplicate of J00C01 | J00C09 | 12/11/2002 | 3.5E+00 | | 3.9E-01 | 4.2E-01 | U | 4.2E-01 | -6.25E-01 | U | 2.90E+00 | 4.10E-02 | U | 4.10E-02 | 4.30E-02 | U | 4.30E-02 | 9.90E-02 | U | 9.90E-02 | 1.40E-01 | U | 1.40E-01 |
| OA2 | J00C02 | 12/11/2002 | 3.5E+00 | | 4.1E-01 | 4.3E-01 | U | 4.3E-01 | 1.66E-01 | U | 1.80E+00 | 4.50E-02 | U | 4.50E-02 | 4.90E-02 | U | 4.90E-02 | 1.10E-01 | U | 1.10E-01 | 1.60E-01 | U | 1.60E-01 |
| OA3 | J00C03/J00HL9[a] | 12/11/2002, 2/26/03[a] | 3.8E+00 | | 4.0E-01 | 0.42[a] | U | 4.2E-01 | 4.12E-01 | U | 1.90E+00 | 3.90E-02 | U | 3.90E-02 | 4.00E-02 | U | 4.00E-02 | 9.00E-02 | U | 9.00E-02 | 1.40E-01 | U | 1.40E-01 |
| OA4 | J00C04 | 12/11/2002 | 1.0E+01 | | 3.9E-01 | 4.2E-01 | U | 4.2E-01 | 8.10E-02 | U | 1.80E+00 | 5.30E-02 | U | 5.30E-02 | 4.80E-02 | U | 4.80E-02 | 1.10E-01 | U | 1.10E-01 | 1.50E-01 | U | 1.50E-01 |
| OB5 | J00C05 | 12/11/2002 | 1.6E+01 | | 4.0E-01 | 4.2E-01 | U | 4.2E-01 | -1.02E+00 | U | 2.90E+00 | 4.00E-02 | U | 4.00E-02 | 4.10E-02 | U | 4.10E-02 | 8.70E-02 | U | 8.70E-02 | 1.40E-01 | U | 1.40E-01 |
| OB6 | J00C06 | 12/11/2002 | 1.2E+01 | | 3.7E-01 | 4.2E-01 | U | 4.2E-01 | -1.13E-01 | U | 3.40E+00 | 6.10E-02 | U | 6.10E-02 | 3.90E-02 | U | 3.90E-02 | 9.00E-02 | U | 9.00E-02 | 1.40E-01 | U | 1.40E-01 |
| OB7 | J00C07 | 12/11/2002 | 1.0E+01 | | 3.8E-01 | 4.2E-01 | U | 4.2E-01 | 2.30E+00 | U | 3.50E+00 | 5.40E-02 | U | 5.40E-02 | 5.70E-02 | U | 5.70E-02 | 1.10E-01 | U | 1.10E-01 | 2.00E-01 | U | 2.00E-01 |
| OB8 | J00C08 | 12/11/2002 | 5.0E+00 | | 4.0E-01 | 4.3E-01 | U | 4.3E-01 | -1.15E+00 | U | 3.30E+00 | 4.00E-02 | U | 4.00E-02 | 4.00E-02 | U | 4.00E-02 | 8.50E-02 | U | 8.50E-02 | 1.20E-01 | U | 1.20E-01 |

[a]These areas were resampled on the indicated dates following additional remediation, and reanalyzed for the indicated COCs

**Statistical Computation Input Data**

| Sample Point | HEIS Number | Sample Date | As pCi/g | Cr+6 pCi/g | C-14 pCi/g | Cs-137 pCi/g | Co-60 pCi/g | Eu-152 pCi/g | Eu-154 pCi/g |
|---|---|---|---|---|---|---|---|---|---|
| OA1 | J00C01/J00C09 | 12/11/2002 | 3.4E+00 | 2.1E-01 | -6.91E-01 | 2.13E-02 | 2.25E-02 | 5.23E-02 | 7.75E-02 |
| OA2 | J00C02 | 12/11/2002 | 3.5E+00 | 2.2E-01 | 1.66E-01 | 2.25E-02 | 2.45E-02 | 5.50E-02 | 8.00E-02 |
| OA3 | J00C03/J00HL9[a] | 12/11/2002, 2/26/03[a] | 3.8E+00 | 2.1E-01 | 4.12E-01 | 1.95E-02 | 2.00E-02 | 4.50E-02 | 7.00E-02 |
| OA4 | J00C04 | 12/11/2002 | 1.0E+01 | 2.1E-01 | 8.10E-02 | 2.65E-02 | 2.40E-02 | 5.50E-02 | 7.50E-02 |
| OB5 | J00C05 | 12/11/2002 | 1.6E+01 | 2.1E-01 | -1.02E+00 | 2.00E-02 | 2.05E-02 | 4.35E-02 | 7.00E-02 |
| OB6 | J00C06 | 12/11/2002 | 1.2E+01 | 2.1E-01 | -1.13E-01 | 3.05E-02 | 1.95E-02 | 4.50E-02 | 7.00E-02 |
| OB7 | J00C07 | 12/11/2002 | 1.0E+01 | 2.1E-01 | 2.30E+00 | 2.70E-02 | 2.85E-02 | 5.50E-02 | 1.00E-01 |
| OB8 | J00C08 | 12/11/2002 | 5.0E+00 | 2.2E-01 | -1.15E+00 | 2.00E-02 | 2.00E-02 | 4.25E-02 | 6.00E-02 |

**Statistical Computations**

| | As | Cr+6 | C-14 | Cs-137 | Co-60 | Eu-152 | Eu-154 |
|---|---|---|---|---|---|---|---|
| Statistical value based on | Small data set. Use nonparametric z-stat | >50% Below Detection. Default to Maximum Value | Radionuclide data set. Use nonparametric z-stat | Radionuclide data set. Use nonparametric z-stat | Radionuclide data set. Use nonparametric z-stat | Radionuclide data set. Use nonparametric z-stat | Radionuclide data set. Use nonparametric z-stat |
| N | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| % < Detection limit | 0% | 114% | 100% | 100% | 100% | 100% | 100% |
| mean | 8.0E+00 | 2.1E-01 | -1.88E-03 | 2.34E-02 | 2.24E-02 | 4.92E-02 | 7.53E-02 |
| st. dev. | 4.7E+00 | 2.3E-03 | 1.09E+00 | 4.08E-03 | 3.11E-03 | 5.64E-03 | 1.17E-02 |
| Z-statistic | 1.645 | 1.645 | 1.645 | 1.645 | 1.645 | 1.645 | 1.645 |
| 95%UCL on mean | 1.1E+01 | 2.1E-01 | 8.33E-01 | 2.58E-02 | 2.42E-02 | 5.24E-02 | 8.21E-02 |
| max value | 1.8E+01 | 4.3E-01 U | 2.3E+00 U | 6.1E-02 U | 5.7E-02 U | 1.1E-01 U | 2.0E-01 U |
| Statistical value | 1.1E+01 | 4.3E-01 | 8.33E-01 | 2.58E-02 | 2.42E-02 | 5.24E-02 | 8.21E-02 |
| Background | NA | NA | NA | 1.1 | 0.008 | NA | 0.033 |
| Statistical value above background | 1.1E+01 | 4.3E-01 | 8.33E-01 U | 0 (< BG) U | 1.62E-02 U | 5.24E-02 U | 4.91E-02 U |
| Lookup Value - 15 mrem/yr for rec | | | 5.16 | 6.2 | 1.4 | 3.3 | 3.0 |
| Most Stringent Cleanup Limit for nonradionuclide and RAG Type | 20 River Protection, Hanford Site Background | 2 River Protection | | | | | |
| **WAC 173-340 3-PART TEST** | | | | | | | |
| 95% UCL > Cleanup Limit? | NO | NO | | | | | |
| > 10% above Cleanup Limit? | NO | NO | | | | | |
| Any sample > 2X Cleanup Limit? | NO | NO | | | | | |
| **EXCESS RISK EVALUATION** | | | | | | | |
| WAC 173-340 B Non-Carcinogenic Cleanup | 24 | 400 | | | | | |
| Hazard quotient for each nonradionuclide: | NA | 1.1E-03 | | | | | |
| WAC 173-340 B Carcinogenic Cleanup | 0.67 | 2.1 | | | | | |
| Excess risk for each carcinogenic nonradionuclide: | NA | 2.0E-07 | | | | | |
| **NON-RAD SUMMARY** | Because statistical value for arsenic is below Hanford Site background, the hazard quotient and excess risk are not calculated. | | | | | | |

| | |
|---|---|
| WAC 173-340 3-Part-Test Compliance: | NA |
| Nonrad noncarcinogenic sum of | 1.08E-03 |
| Nonrad carcinogenic risk: | 2E-07 |

Bechtel Hanford, Inc.

**CALCULATION SHEET**

Originator: J. E. Thomson
Project: 116-F-1 Cleanup Verification
Subject: 116-F-1 Cleanup Verification 95% UCL Calculation

Date: 5/24/03
Job No.: 22192

Calc. No.: 0100F-CA-V0138
Checked by: S. W. Callison 3/25 / T.B. Miley 3/25

Rev. No.: 0
Date: 3-25-03 / 3-25-03
Sheet No.: 6 of 8

**116-F-1 Split/Duplicate Analysis:**

| Sample Area | HEIS Number | As pCi/g | | As MDA | Cr+6 pCi/g | | Cr+6 MDA | C-14 pCi/g | Q | C-14 MDA | Cs-137 pCi/g | Q | Cs-137 MDA | Co-60 pCi/g | Q | Co-60 MDA | Eu-152 pCi/g | Q | Eu-152 MDA | Eu-154 pCi/g | Q | Eu-154 MDA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **116-F-1 Shallow Zone Results:** | | | | | | | | | | | | | | | | | | | | | | |
| SA1 | J00FF9 | 3.0E+00 | | 4.0E-01 | 4.3E-01 | U | 4.3E-01 | 2.75E-01 | U | 3.40E+00 | 1.35E-01 | | 8.90E-02 | 8.50E-02 | U | 8.50E-02 | 1.90E-01 | U | 1.90E-01 | 2.20E-01 | U | 2.20E-01 |
| Duplicate of J00FF9 | J00FH0 | 4.1E+00 | | 4.0E-01 | 4.3E-01 | U | 4.3E-01 | 3.81E-01 | U | 8.03E-01 | 6.94E-02 | | 1.86E-02 | 9.65E-03 | U | 2.01E-02 | 1.34E-01 | U | 5.40E-02 | 4.27-03 | U | 6.00E-02 |
| Split of J00FF9 | J00FK9 | 3.3E+00 | | 1.0E-01 | 1.1E+01 | | 1.2E-01 | 2.77E-01 | U | 8.07E-01 | 6.35E-02 | | 2.36E-02 | -1.70E-03 | U | 2.11E-02 | 7.42E-02 | U | 6.44E-02 | -3.24E-03 | U | 7.06E-02 |
| SD5 | J00FJ4 | 7.7E+00 | | 2.9E-01 | 4.3E-01 | U | 4.3E-01 | 2.06E+00 | U | 2.70E+00 | 6.30E-02 | | 4.30E-02 | 4.20E-02 | U | 4.20E-02 | 1.00E-01 | U | 1.00E-01 | 1.30E-01 | U | 1.30E-01 |
| Duplicate of J00FJ4 | J00FJ5 | 6.0E+00 | | 3.3E-01 | 4.8E-01 | U | 4.8E-01 | 2.85E+00 | | 2.60E+00 | 1.30E-01 | U | 1.00E-01 | 1.00E-01 | U | 1.00E-01 | 2.30E-01 | U | 2.30E-01 | 2.90E-01 | U | 2.90E-01 |
| Split of J00FJ4 | J00FL0 | 6.3E+00 | | 1.1E-01 | -2.6E-02 | U | 8.00E.02 | -2.51E-01 | U | 8.07E-01 | 6.85E-02 | | 2.26E-02 | -2.35E-03 | U | 2.14E-02 | 1.95E-01 | U | 6.55E-02 | 7.06E-03 | U | 6.80E-02 |
| **116-F-1 Overburden Results:** | | | | | | | | | | | | | | | | | | | | | | |
| OA1 | J00C01 | 3.3E+00 | | 4.0E-01 | 4.3E-01 | U | 4.3E-01 | 1.77E+00 | U | 5.90E-02 | 4.50E-02 | U | 4.50E-02 | 5.80E-02 | U | 5.80E-02 | 1.00E-01 | U | 1.00E-01 | 1.70E-01 | U | 1.70E-01 |
| Duplicate of J00C01 | J00C09 | 3.5E+00 | | 3.9E-01 | 4.2E-01 | U | 4.2E-01 | -1.58E+00 | U | 4.40E+00 | 4.10E-02 | U | 4.10E-02 | 4.50E-02 | U | 4.50E-02 | 9.50E-02 | U | 9.50E-02 | 1.50E-01 | U | 1.50E-01 |
| Split of J00C01 | J00C11 | 2.7E+00 | | 1.0E-01 | 2.4E-02 | U | 8.0E-02 | 1.70E-02 | U | 3.16E-01 | 4.15E-02 | U | 2.10E-02 | 1.43E-02 | U | 2.40E-02 | -1.53E-02 | U | 8.43E | 3.85E-03 | U | 6.56E-02 |

**Shallow Zone Analysis:**

| | (TDL) | 0.5 | 0.5 | 50 | 0.1 | 0.05 | 0.1 | 0.1 |
|---|---|---|---|---|---|---|---|---|
| Duplicate Analysis | Both> MDA? | Yes (continue) | No-Stop (acceptable) | No-Stop (acceptable) | Yes (continue) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) |
| | Both >5xTDL? | Yes (calc RPD) | | | No-Stop (acceptable) | | | |
| | RPD | 31% | | | | | | |
| Split Analysis | Both> MDA? | Yes (continue) | No-Stop (acceptable) | No-Stop (acceptable) | Yes (continue) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) |
| | Both >5xTDL? | Yes (calc RPD) | | | No-Stop (acceptable) | | | |
| | RPD | 9.5% | | | | | | |

**Shallow Zone Analysis:**

| | (TDL) | 0.5 | 0.5 | 50 | 0.1 | 0.05 | 0.1 | 0.1 |
|---|---|---|---|---|---|---|---|---|
| Duplicate Analysis | Both> MDA? | Yes (continue) | No-Stop (acceptable) | No-Stop (acceptable) | Yes (continue) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) |
| | Both >5xTDL? | Yes (calc RPD) | | | No-Stop (acceptable) | | | |
| | RPD | 25% | | | | | | |
| Split Analysis | Both> MDA? | Yes (continue) | No-Stop (acceptable) | No-Stop (acceptable) | Yes (continue) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) |
| | Both >5xTDL? | Yes (calc RPD) | | | No-Stop (acceptable) | | | |
| | RPD | 20% | | | | | | |

**Overburden Analysis:**

| | (TDL) Both> | 0.5 | 0.5 | 50 | 0.1 | 0.05 | 0.1 | 0.1 |
|---|---|---|---|---|---|---|---|---|
| Duplicate Analysis | MDA? | Yes (continue) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) |
| | Both >5xTDL? | Yes (calc RPD) | | | | | | |
| | RPD | 5.9% | | | | | | |
| Split Analysis | Both> MDA? | Yes (continue) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) | No-Stop (acceptable) |
| | Both >5xTDL? | Yes (calc RPD) | | | | | | |
| | RPD | 20% | | | | | | |

# CALCULATION COVER SHEET

**Project Title** 116-F-1 Lewis Canal Cleanup Verification **Job No.** 22192
**Area** 100-F Area
**Discipline** Environmental ***Calc. No.** 0100F-CA-V0140
**Subject** 116-F-1 Lewis Canal RESRAD Calculation
**Computer Program** RESRAD **Program No.** Version 6.21

Use of this calculation by persons who do not have access to all of the pertinent facts could lead to incorrect conclusions or assumptions. Before applying this calculation in your work, this calculation must be thoroughly reviewed with appropriate and authorized Hanford site ERC personnel. Without this review, the ERC cannot assume any responsibility for the use of these calculations.

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

| Rev. | Sheet Numbers | Originator | Checker | Reviewer | Approval | Date |
|---|---|---|---|---|---|---|
| 0 | Cover – 1 pg<br>Summary – 5 pg<br>Attm. 1 - 1 pg<br>Attm. 2 - 20 pg<br>Attm. 3 - 20 pg<br>Attm. 4 - 10 pg<br>Attm. 5 - 20 pg<br>Attm. 6 - 20 pg<br>Attm. 7 - 10 pg<br>Total – 107 pages | J. E. Thomson<br>J.E. Thom<br>3/10/03 | S. W. Clark<br>SW Clark<br>3/10/03 | K. E. Cook<br>KE Cook<br>3/11/03 | M. A. Buckmaster<br>3/18/03 | 3/18/03 |
| | | | | | | |
| | | | | | | |

**SUMMARY OF REVISION**

*Obtain Calc. No. from DIS
DE01-437.03

January 2003

Bechtel Hanford, Inc. CALCULATION SHEET

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Originator: | J. E. Thomson | Date: | 3/10/03 | Calc. No.: | 0100F-CA-V0140 | Rev.: | 0 |
| Project: | 116-F-1 Cleanup Verification | Job No: | 22192 | Checked: | S. W. Clark | Date: | 3/10/03 |
| Subject: | 116-F-1 Lewis Canal RESRAD Calculation | | | | | Sheet No. | 1 of 5 |

**PURPOSE:**

Calculate the soil and groundwater concentrations, dose, and risk contributions from remaining radionuclide contaminants in vadose zone and overburden soil at the 116-F-1 Lewis Canal remediation site over a period of 1,000 years.

**GIVEN/REFERENCES:**

1. Cleanup verification data from *116-F-1 Lewis Canal Cleanup Verification 95% UCL Calculation*, Calculation No. 0100F-CA-V0138, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.
2. *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP), DOE/RL-96-17, Rev. 4, 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. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington. For the purpose of these RESRAD calculations, the radioactive contaminants of concern (COCs) are carbon-14, cobalt-60, cesium-137, europium-152, and Europium-154. Arsenic and hexavalent chromium are the nonradionuclide COCs.
4. RESidual RADioactivity (RESRAD) computer code, version 6.21, 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 *116-F-1 Lewis Canal Shallow Zone and Overburden Sampling Design*, Calculation No. 0100F-CA-V0154, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.
6. *Group 4 Status Meeting with EPA*, CCN 100107, ERC Team meeting minutes, dated July 8, 2002, Bechtel Hanford, Inc., Richland, Washington. The distribution coefficient (Kd value) for carbon-14 was changed to 200 mL/g (from 0 mL/g in the RDR/RAWP) based on the 100-F Area Leachability Study results (Appendix D of CVP-2001-00002), and on concurrence with the regulators documented in these meeting minutes.
7. Ecology, EPA, and DOE, 1998, *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.

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|---|---|---|---|---|---|---|---|
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| Project: | 116-F-1 Cleanup Verification | Job No: | 22192 | Checked: | S. W. Clark | Date: | 3/19/03 |
| Subject: | 116-F-1 Lewis Canal RESRAD Calculation | | | | | Sheet No. | 2 of 5 |

**SOLUTION:**

1) Separate RESRAD runs were performed for the vadose zone and for overburden. The cleanup verification sample data was used to conservatively represent the entire vadose zone below the site. It was conservatively assumed that the concentrations of contaminants detected in the shallow zone soils were consistent to the groundwater table to simplify the process for estimating dose, excess lifetime cancer risk, and groundwater concentrations at the 116-F-1 site. Table 1 shows the elevations (NAVD'88) and dimensions of the vadose zone and overburden. The backfill reference elevation for the excavation is 120.6 m, the elevation at the bottom of the excavation is 116.1 m, and the groundwater elevation beneath the site is 114.2 m. Attachment 1 shows the dimensions of the soil horizon and the contaminant pathways considered for dose, risk, and groundwater protection. A separate RESRAD run was performed using the verification samples collected from the overburden soils. Because overburden soil was used to backfill the site excavation, the contaminated zone thickness model assumes that the contamination is equal to the depth of the remedial site excavation. RESRAD input parameters for each run are shown in the "Summary" section of the RESRAD "Part I: Mixture Sums and Single Radionuclide Guidelines" printouts in the Attachments to this Calculation Summary.

**Table 1. Dimensions and Elevations (NAVD'88) of 116-F-1 Soil Horizons**

| RESRAD Run # | Vadose Zone Horizon | Upper Elevation (m) | Lower Elevation (m) | Thickness (m) |
|---|---|---|---|---|
| 1 | Vadose Zone | 120.6 | 114.2 | 6.4 |
| 2 | Overburden | 120.6 | 116.1 | 4.5 |

2) The year where the peak dose (or concentration) occurs from each individual radionuclide COC and layer is determined by a preliminary run. This year is then included for all horizons for the final RESRAD runs. For the direct exposure pathway (i.e. soil ingestion and inhalation and external radiation), the peak year occurred at year zero (2003) for all radionuclide COCs. For the water pathway (i.e. drinking water and food ingestion) the peak year was 7.1 for cobalt-60, and 43 for cesium-137. The 7.1 and 43-year time-periods were included in all RESRAD runs. The year 2018 is included for evaluation in all horizons (the year 15 time-period) as 2018 corresponds to the 30-year site cleanup schedule of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1998).

**METHODOLOGY:**

1) Runs of RESRAD version 6.21 were completed for the shallow zone and overburden soil concentrations shown in Table 2. RESRAD numerical output reports for radionuclide dose, risk, and concentration for the vadose zone and overburden are presented in the Attachments to this Calculation Summary. Shallow zone and overburden concentrations of

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hexavalent chromium are included in Table 2 for evaluation of their potential to affect groundwater or the Columbia River.

**Table 2. 116-F-1 Cleanup Verification Data Set**

| Radionuclide COCs | Radionuclide Activity, pCi/g | |
|---|---|---|
| | Shallow Zone[a] | Overburden[a] |
| C-14 | 1.47E+00 | 6.33E-01 (U) |
| Cs-137 | 1.10E-01 | 0 (<BG) (U) |
| Co-60 | 5.49E-02 (U) | 1.62E-02 (U) |
| Eu-152 | 1.77E-01 | 5.24E-02 (U) |
| Eu-154 | 1.37E-01 (U) | 4.91E-02 (U) |
| **Nonradionuclide COCs** | **Nonradionuclide Concentration, mg/kg** | |
| As | 8.0E+00[b] | 1.1E+01[b] |
| Cr (VI) | 1.5E+00[b] | 4.3E-01 (U)[b] |

[a] The shallow zone and overburden concentrations are from the *116-F-1 Lewis Canal Cleanup Verification 95% UCL Calculation*, Calculation No. 0100F-CA-V0140, Rev. 0.
[b] Value was not input into RESRAD because the concentration is below RAGs, below Hanford Site background, below Washington State background, or because the analyte was not detected in cleanup verification samples at the indicated detection limits.
U = All analytical results for the data set were below laboratory detection limits.

## RESULTS:

### 1) Radionuclide "All Pathways" Dose Rate

The "all pathways" (maximum) dose rates are shown in Table 3. The maximum dose rate for the 116-F-1 vadose zone is 5.61 mrem/yr and occurs at present (2003). The maximum overburden dose rate of 1.87 mrem/yr occurs at present (2003). The all pathways dose rate at year 2018 (time slice 15) is 0.836 mrem/yr for the vadose zone and 0.201 mrem/yr for the overburden.

**Table 3. All Pathways Dose Rate (mrem/yr)**

| RESRAD Run # | Vadose Zone Horizons | "All Pathways" Dose Contributions in mrem/yr at Each Time Slice (yr) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 3 | 7.1 | 15 | 43 | 100 | 300 | 1000 |
| 1 | Vadose Zone | 5.61E+00 | 3.32E+00 | 1.97E+00 | 1.37E+00 | 8.36E-01 | 2.13E-01 | 3.32E-02 | 2.96E-04 | 2.81E-11 |
| 2 | Overburden | 1.87E+00 | 8.73E-01 | 5.08E-01 | 3.58E-01 | 2.01E-01 | 3.32E-02 | 1.36E-03 | 3.82E-08 | 9.05E-17 |

### 2) Radionuclide Excess Cancer Risk

The radionuclide excess lifetime cancer risk results are shown in Table 4. The maximum excess lifetime cancer risk for vadose zone soil ($2.81 \times 10^{-5}$) occurs at present (2003). The maximum risk from overburden soil ($7.39 \times 10^{-6}$) occurs at present (2003). The excess lifetime

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|---|---|---|---|---|---|---|---|
| Originator: | J. E. Thomson | Date: | 3/10/03 | Calc. No.: | 0100F-CA-V0140 | Rev.: | 0 |
| Project: | 116-F-1 Cleanup Verification | Job No: | 22192 | Checked: | S. W. Clark | Date: | 3/10/03 |
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cancer risk at year 2018 (time slice 15) is 9.80 x $10^{-6}$ for the vadose zone and 2.04 x $10^{-6}$ for the overburden.

**Table 4. Radionuclide Excess Lifetime Cancer Risk**

| RESRAD Run # | Vadose Zone Horizons | Excess Cancer Risk at Each Time Slice (yr) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 3 | 7.1 | 15 | 43 | 100 | 300 | 1000 |
| 1 | Vadose Zone | 2.81E-05 | 2.35E-05 | 1.94E-05 | 1.50E-05 | 9.80E-06 | 2.93E-06 | 5.24E-07 | 4.85E-09 | 4.58E-16 |
| 2 | Overburden | 7.39E-06 | 5.79E-06 | 4.70E-06 | 3.49E-06 | 2.04E-06 | 3.66E-07 | 1.58E-08 | 4.50E-13 | 6.09E-22 |

### 3) Radionuclide Groundwater Protection

The radionuclide concentrations in groundwater calculated by the RESRAD model are summarized in Table 5. The organ specific dose via the groundwater (and river) pathway is calculated in a separate calculation brief. Only concentrations are presented here. Cobalt-60 and cesium-137 were calculated to reach groundwater in the 1,000 years of the RESRAD model run for the vadose zone. These radionuclide contaminants reach groundwater at concentrations significantly below the RAGs.

**Table 5. RESRAD Predicted Groundwater (Well Water/Drinking Water) Concentrations**

| COC | Vadose Zone Horizon | Groundwater Concentrations in pCi/L at Each Time Slice (yr) | | | | | | | | | RAGs From RDR (pCi/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 3 | 7.1 | 15 | 43 | 100 | 300 | 1000 | |
| C-14 | Vadose Zone | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2000 |
| | Overburden | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Co-60 | Vadose Zone | 0 | 1.24E-04 | 9.10E-05 | 3.94E-04 | 2.95E-04 | 2.12E-05 | 2.73E-08 | 3.07E-19 | 0 | 100 |
| | Overburden | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Cs-137 | Vadose Zone | 0 | 2.77E-04 | 7.93E-04 | 1.71E-03 | 3.00E-03 | 4.50E-03 | 2.79E-03 | 8.15E-05 | 1.46E-11 | 60 |
| | Overburden | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Eu-152 | Vadose Zone | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 |
| | Overburden | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Eu-154 | Vadose Zone | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| | Overburden | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

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|---|---|---|---|---|---|---|---|
| Originator: | J. E. Thomson | Date: | 3/10/03 | Calc. No.: | 0100F-CA-V0140 | Rev.: | 0 |
| Project: | 116-F-1 Cleanup Verification | Job No: | 22192 | Checked: | S. W. Clark | Date: | 3/10/03 |
| Subject: | 116-F-1 Lewis Canal RESRAD Calculation | | | | | Sheet No. | 5 of 5 |

**CONCLUSIONS:**

- The maximum vadose zone all pathways dose rate of 5.61 mrem/yr occurs at present (in year 2003). The maximum overburden dose rate of 1.87 mrem/yr occurs at present (in year 2003). The dose rate in year 2018 is 0.836 mrem/yr for the vadose zone and 0.201 mrem/yr for the overburden.

- The dominant pathway for the dose rate is direct external exposure.

- The primary radionuclide contributing to the direct exposure pathway dose rate is europium-152.

- The maximum excess lifetime cancer risk for vadose zone soil ($2.81 \times 10^{-5}$) occurs at present (in year 2003). The maximum risk from overburden soil ($7.39 \times 10^{-6}$) occurs at present (in year 2003). The excess lifetime cancer risk in year 2018 is $9.80 \times 10^{-6}$ for the vadose zone and $2.04 \times 10^{-6}$ for the overburden.

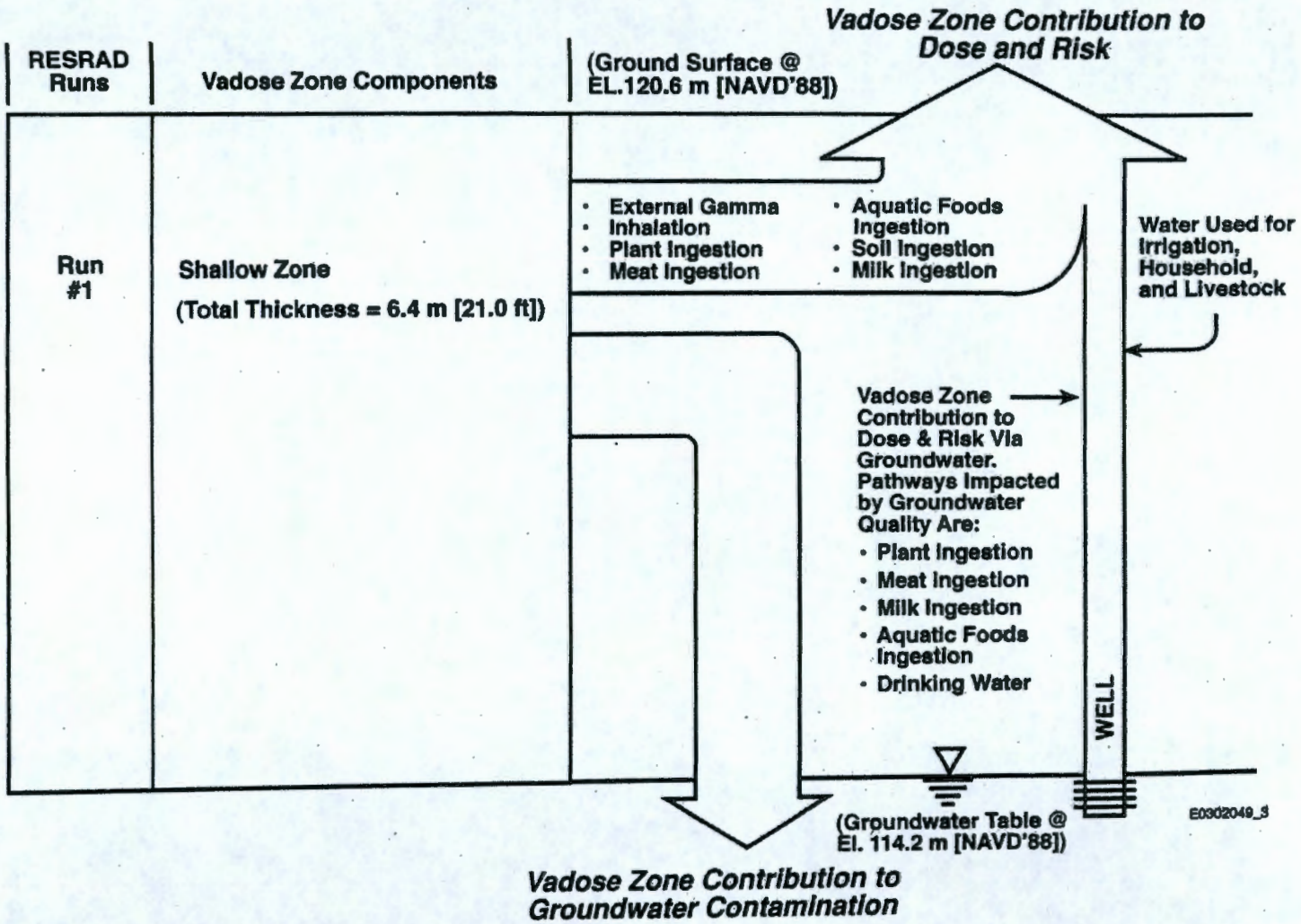
- Among the radionuclide contaminants of concern, cobalt-60 and cesium-137 are calculated to reach groundwater in the 1,000 years of the RESRAD model run. These radionuclides are predicted to reach groundwater at concentrations significantly below the RAGs.

- None of the site COCs are projected to exceed remedial action goals (RAGs).

**ATTACHMENTS:**

1. Graphic showing 116-F-1 Cleanup Verification Model (1 page)
2. RESRAD Output: 116-F-1 Vadose Zone Rad (Run 1), Mixture Sums and Single Radionuclide Guidelines (20 pages)
3. RESRAD Output: 116-F-1 Vadose Zone Rad (Run 1), Intake Quantities and Health Risk Factors (20 pages)
4. RESRAD Output: 116-F-1 Vadose Zone Rad (Run 1), Concentration of Radionuclides (10 pages)
5. RESRAD Output: 116-F-1 Overburden Rad (Run 2), Mixture Sums and Single Radionuclide Guidelines (20 pages)
6. RESRAD Output: 116-F-1 Overburden Rad (Run 2), Intake Quantities and Health Risk Factors (20 pages)
7. RESRAD Output: 116-F-1 Overburden Rad (Run 2), Concentration of Radionuclides (10 pages)

# 116-F-1 Cleanup Verification Model




Attachment 1 Sheet No. 1 of 1
Originator J. E. Thomson Date 3/6/03
Chk'd By S. W. Clark Date 3/6/03
Calc. No. 0100F-CA-V0140 Rev. No. 0

# CALCULATION COVER SHEET

| | | | |
|---|---|---|---|
| **Project Title:** | 116-F-1 Lewis Canal Cleanup Verification | **Job No.** | 22192 |
| **Area** | 100-F Area | | |
| **Discipline** | Environmental | ***Calc. No.** | 0100F-CA-V0139 |
| **Subject** | 116-F-1 Lewis Canal Comparison to Drinking Water Standards (MCL) | | |
| **Computer Program** | Excel | **Program No.** | Excel 97 |

Use of this calculation by persons who do not have access to all of the pertinent facts could lead to incorrect conclusions or assumptions. Before applying this calculation in your work, this calculation must be thoroughly reviewed with appropriate and authorized Hanford site ERC personnel. Without this review, the ERC cannot assume any responsibility for the use of these calculations.

**Committed Calculatio** X **Preliminary** **Superseded**

| Rev. | Sheet Numbers | Originator | Checker | Reviewer | Approval | Date |
|---|---|---|---|---|---|---|
| 0 | Cover - 1<br>Calculations - 3<br>Total - 4 | J. E. Thomson<br>*Approved 3/10/03* | S. W. Clark<br>*Approved 3/10/03* | K. E. Cook<br>*Approved 3/11/03* | M. A. Buckmaster<br>*Approved 3/18/03* | *Approved 3/18/03* |
| 1 | Cover - 1<br>Calculations - 3<br>Total - 4 | J. E. Thomson<br>J.E. Thomson 4/4/03 | S. W. Clark<br>S W Clark 4/4/03 | K. E. Cook<br>KE Cook 4/4/03 | M. A. Buckmaster<br>4/15/03 | 4/15/03 |
| | | | | | | |

**SUMMARY OF REVISIONS**

| | |
|---|---|
| 1 | Revision was necessary to correct incorrect data for Cs-137 entered on page 2. The Conclusions on page 1 are not affected. The entire calculation brief was replaced for convenience. |

*Obtain Calc. No. from DIS

January 2003

DE01-437.03

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**Bechtel Hanford, Inc.** **CALCULATION SHEET**

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|---|---|---|---|---|---|---|---|
| Originator | J. E. Thomson | Date | 4/4/03 | Calc. No. 0100F-CA-V0139 | | Rev. No. | 1 |
| Project | 116-F-1 Lewis Canal CVP | Job No. | 22192 | Checked S. W. Clark | | Date | 4/4/03 |
| Subject | 116-F-1 Lewis Canal Comparison to Drinking Water Standards (MCL) | | | | | Sheet No. | 1 of 3 |

**Purpose:**
Compare RESRAD derived groundwater radionuclide concentrations to remedial action goals and maximum contaminant levels (MCLs) for groundwater. Compare beta/gamma emitter dose contributions to the maximum allowable dose of 4 mrem/yr. Compare alpha emitter dose contributions to the maximum allowable gross particle activity of 15 pCi/L.

**Table of Contents:**
1. Calculation Summary
2. Comparison to MCLs
3. Cumulative Dose Comparison

**Given/References:**
1) RESRAD derived groundwater radionuclide concentrations from Calculation 0100F-CA-V0140, *116-F-1 Lewis Canal RESRAD Calculation*.

2) Remedial action goals for groundwater and MCLs summarized in Table 2-3 of the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP), DOE/RL-96-17, Rev. 4, U.S. Department of Energy, Richland Operations office, Richland, WA.

3) Maximum allowable dose of 4 mrem/yr for beta/gamma emittersand maximum allowable gross particle activity of 15 pCi/L for alpha emitters from: 40 CFR 141, "National Primary Drinking Water Regulation," *Code of Federal Regulations*, as amended (40 CFR Part 141, Subpart B, 141.51).

4) Individual organ-dose caclulation methodology for beta/gamma emitter dose contribution to the maximum allowable dose of 4 mrem/yr from: *Maximum Permissible Body Burdens and Maximum Permissible Concetrations of Radionuclides in Air or Water for Occupational Exposure*, National Bureau of Standards (NBS) Handbook 69, as amended, U.S. Department of Commerce, Washington D.C., and National Primary Drinking Water Regulations, EPA-570/9-76-003, U.S. Environmental Protection Agency, Office of Water Supply, Washington D.C.

**Solution:**
1. The site data for the calculation are the groundwater concentrations for the contaminants of concern (COCs) (daughter products are not considered) over time from the RESRAD groundwater concentration file.

2. If the site conceptual model breaks the contamination into multiple layers with differing concentrations, then the groundwater concentrations from the various model runs are added (for each time interval) to provide the concentration data for comparison to the individual remedial action goals and MCLs and the dose calculation for the beta and gamma emitters.

3. Compare the summed concentrations for each radionuclide to the groundwater remedial action goal and MCL given in the RDR/RAWP, Table 2-3.

4. The cumulative dose for each organ for all beta and gamma emitting COCs (C-14, Co-60, Cs-137, Eu-152, and Eu-154) at time t is calculated separately using the corresponding to 4 mrem/year dose (C4) and the sum of fractions equation shown below (from EPA-570/9-76-003). The organs for which doses need to be computed are total body, bone, liver and gastrointestinal tract [lower large intestine] (GI(LLI)). The individual organ doses are compared to 4 mrem/yr.

Doseorgan x (t) = [ConcA(t)/C4A(x) + ConcB(t)/C4B(x) + ....] x (4 mrem/yr)

where:
Doseorgan x (t) is the total dose to organ x in mrem/yr
ConcA(t) is the concentration of isotope A at time t in pCi/L
C4A(x) is the 4 mrem/yr dose equivalent concentration for organ x of isotope A at time t in pCi/L
If the dose for organ x < 4 mrem/yr, then the standard is met.

**Conclusions:**
1. The summed concentrations for each radionuclide COC are less than the groundwater remedial action goal and MCL given in the RDR/RAWP, Table 2-3.

2. The cumulative dose for each total body, bone, liver and gastrointestinal tract for all beta and gamma emitting COCs is less than 4 mrem/yr

3. There are no alpha emitters among the radionuclide COCs at this site. Therefore, the summed concentrations for the alpha emitting COCs are less than the maximum allowable gross particle activity of 15 pCi/L.

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**CALCULATION SHEET**

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| **Originator** | J. E. Thomson | **Date** 4/4/03 | **Calc. No.** 0100F-CA-V0139 | **Rev. No.** 1 |
| **Project** | 116-F-1 Lewis Canal Cleanup Verification | **Job** 22192 | **Checked** S. W. Clark | **Date** 4/4/03 |
| **Subject** | 116-F-1 Lewis Canal Comparison to Drinking Water Standards (MCL) | | | **Sheet No.** 2 of 3 |

**Comparison of the summed concentrations for each radionuclide to the GW MCL**
**Data derived from RESRAD modelling, units are pCi/L.**

| Radionuclide | Time (years) 0 | 1 | 3 | 7.3 | 16 | 43 | 100 | 300 | 1000 | MCL | Exceeds MCL? | Peak Conc. | Year of Peak |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,000 | No | 0 | 0 |
| Cs-137 | 0 | 2.77E-04 | 7.93E-04 | 1.71E-03 | 3.00E-03 | 4.50E-03 | 2.79E-03 | 8.15E-05 | 1.46E-11 | 60 | No | 4.50E-03 | 43 |
| Co-60 | 0 | 2.91E-03 | 6.75E-03 | 9.34E-03 | 6.53E-03 | 5.03E-04 | 6.49E-07 | 7.33E-18 | 0 | 100 | No | 9.34E-03 | 7.3 |
| Eu-152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | No | 0 | 0 |
| Eu-154 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 60 | No | 0 | 0 |

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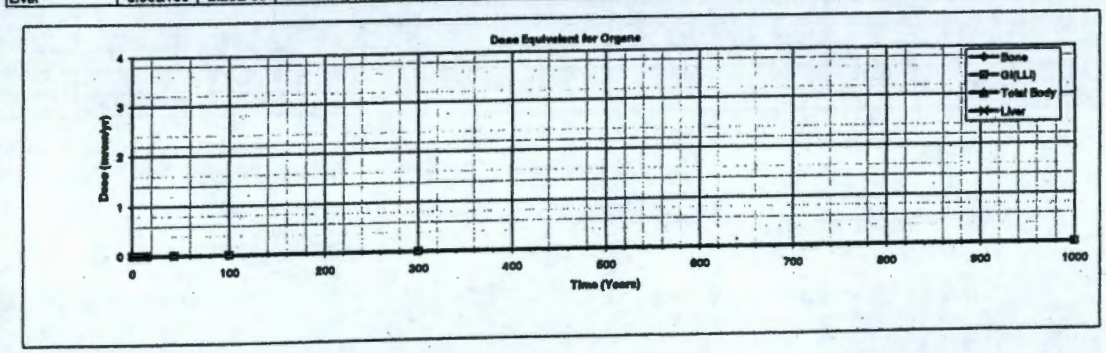
| Originator | J. E. Thomson | Date 4/4/03 | Calc. No. 0100F-CA-V0139 | | Rev. No. 1 |
| Project | 116-F-1 Lewis Canal Cleanup Verification | Job 22192 | Checked S. W. Clark | | Date 4/4/03 |
| Subject | 116-F-1 Lewis Canal Comparison to Drinking Water Standards (MCL) | | | | Sheet No. 3 of 3 |

Comparison of the summed concentrations for each radionuclide to the GW MCL
Data derived from RESRAD modeling, units are pCi/L.

| Radionuclide | Time (years) 0 | 1 | 3 | 7.1 | 15 | 43 | 100 | 300 | 1000 | Organ | $C_i$ | Exceeds 4 mrem/yr? | Peak Conc. | Year of Peak Conc. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Total Body | 9,000 | No | 0 | 0 |
| | | | | | | | | | | Bone | 2,000 | No | | |
| | | | | | | | | | | Fat | 2,000 | No | | |
| Cs-137 | 0 | 2.77E-04 | 7.93E-04 | 1.71E-03 | 3.00E-03 | 4.50E-03 | 2.79E-03 | 8.15E-05 | 1.46E-11 | Bone | 80 | No | 4.50E-03 | 43 |
| | | | | | | | | | | GI(LLI) | 2,000 | No | | |
| | | | | | | | | | | Total Body | 200 | No | | |
| | | | | | | | | | | Liver | 60 | No | | |
| Co-60 | 0 | 2.91E-03 | 6.75E-03 | 9.34E-03 | 6.53E-03 | 5.03E-04 | 6.49E-07 | 7.33E-18 | 0 | GI(LLI) | 100 | No | 9.34E-03 | 7.1 |
| | | | | | | | | | | Total Body | 900 | No | | |
| | | | | | | | | | | Liver | 3,000 | No | | |
| Eu-152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Bone | 30,000 | No | 0 | 0 |
| | | | | | | | | | | GI(LLI) | 200 | No | | |
| | | | | | | | | | | Total Body | 200,000 | No | | |
| | | | | | | | | | | Liver | 100,000 | No | | |
| Eu-154 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Bone | 5,000 | No | 0 | 0 |
| | | | | | | | | | | GI(LLI) | 60 | No | | |
| | | | | | | | | | | Total Body | 70,000 | No | | |
| | | | | | | | | | | Liver | 60,000 | No | | |

Cumulative dose for each organ (with time)

| Organ | Time (years) 0 | 1 | 3 | 7.1 | 15 | 43 | 100 | 300 | 1000 | Exceeds 4 mrem/yr? | Peak Conc. | Year of Peak Conc. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bone | 0.00E+00 | 2.68E-05 | 6.97E-05 | 1.27E-04 | 1.79E-04 | 1.42E-04 | 4.08E-06 | 7.30E-13 | 7.30E-13 | No | 1.79E-04 | 15 |
| GI(LLI) | 0.00E+00 | 1.17E-04 | 2.72E-04 | 3.77E-04 | 2.67E-04 | 2.57E-05 | 1.89E-07 | 2.92E-14 | 2.92E-14 | No | 3.77E-04 | 7.1 |
| Total Body | 0.00E+00 | 1.85E-05 | 4.59E-05 | 7.57E-05 | 8.90E-05 | 5.80E-05 | 1.63E-06 | 2.92E-13 | 2.92E-13 | No | 8.90E-05 | 15 |
| Liver | 0.00E+00 | 2.23E-05 | 6.19E-05 | 1.26E-04 | 2.09E-04 | 1.87E-04 | 5.43E-06 | 9.73E-13 | 9.73E-13 | No | 2.09E-04 | 15 |




Cumulative Dose Comparison

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