IDENTIFICATION OF SELECTED LOCATIONS OF ELEVATED RADIOLOGICAL AND CHEMICAL CONTAMINATION IN SINGLE-SHELL TANK FARMS A, BX, C, and SX

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Abstract: This report is designed to support preliminary risk assessments for zero to 15 ft below ground surface by scaling contaminant levels in soil based on the results of spectral gamma logging of drywells. These modeled contaminant concentrations are documented in RPP-19822, Hanford Defined Waste Model Revision 5.0. Cesium-137 acts as a marker for peak soil concentrations of various contaminants. Because limited data on surface soil exists for the Hanford tank farms, this study is limited to Cesium-137 detected in existing drywells. It should be noted that as a more complete set of drywells is drilled within the farms and as soil samples of surface soil are collected, more complete data will be available. Specific constituent concentrations were extrapolated for individual elevated regions based on peak Cesium-137 concentration values as identified in the gamma logging data.

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LIST OF TERMS

Abbreviations, Acronyms, and Initialisms

CSR	supernate for cesium recovery process
Ecology	Washington State Department of Ecology
FIR	Field Investigation Reports
HDW	Hanford Defined Waste
HEIS	Hanford Environmental Information System
PNNL	Pacific Northwest National Laboratory
PUREX	plutonium-uranium extraction
REDOX	reduction and oxidation
SWITS	Solid Waste Information Tracking System
TCLP	Toxicity Characteristic Leaching Procedure
TF	Tank Farm
TWINS	Tank Waste Information Network System

Units

Ci	curie
ft	foot
keV	kiloelectron volt
kgal	kilogallon
pCi/g	picocurie per gram
SCF	shield correction factor
µCi/g	microcurie per gram

1. INTRODUCTION

This report is designed to support preliminary risk assessments for zero to 15 ft below ground surface by scaling contaminant levels in soil based on the results of spectral gamma logging of drywells. These modeled contaminant concentrations are documented in RPP-19822, *Hanford Defined Waste Model – Revision 5.0*. Cesium-137 acts as a marker for peak soil concentrations of various contaminants.

Because limited data on surface soil exists for the Hanford tank farms, this study is limited to ^{137}Cs detected in existing drywells. It should be noted that as a more complete set of drywells is drilled within the farms and as soil samples of surface soil are collected, more complete data will be available. Specific constituent concentrations were extrapolated for individual elevated regions based on peak ^{137}Cs concentration values as identified in the gamma logging data.

2. DATA REVIEW

A review of the GJO Hanford Tank Farms Vadose Zone Project reports [GJO-HAN-6, *Hanford Tank Farm Vadose Zone Addenda* (BX Farm addendum only)] was conducted to discover potential contaminants of concern that could be utilized as a marker constituent. Criteria for selection included the following:

a. Presence of the constituent.
b. Depth of the constituent.
c. Mobility of the constituent.
d. Constituent half-life.

Constituents present in the top 15 ft of the soil that are considered immobile or less mobile were given precedent over more mobile constituents found at greater depths when identifying the marker contaminant. The least mobile constituents in the top 15 ft of soil are considered the most likely to contribute to the direct exposure risk in the top 15 ft of soil.

The data review for surface soil sampling and information conducted for this document included research into the Hanford Environmental Information System (HEIS), ROCSAN, Tank Farm (TF), Tank Waste Information Network System (TWINS), Solid Waste Information Tracking System (SWITS), and spectral gamma logging databases. Research also included a literature review of Borehole Data Packages and the Hanford Site Environmental Surveillance Data Reports produced at the Pacific Northwest National Laboratory (PNNL), Field Investigation Reports (FIR) for waste management areas B-BX-BY and S-SX, and documents produced detailing site soil background for nonradioactive analytes.

The data review for surface soil data yielded one viable data source. Gamma logging records that delineate the radionuclides present at various soil depths provide the only consistent and valid surface soil data for the tank farms. Other data sources resulted in limited or nonexistent data for potential contaminants of concern in the surface soil. The development of viable activity and concentration values proved problematic because a wide-range near-surface sampling and analysis program has not been conducted in the single-shell tank farms. However, there is extensive near-surface spectral gamma logging data in all of the single-shell tank farms that provide an outstanding footprint of ^{137}Cs activity.

The ROCSAN data was only considered for intervals in boreholes sampled by drive barrel because hard tool drilling pulverizes the sediments so that results are not representative of actual particle size distribution (PNNL-14586, *Geologic Data Package for 2005 Integrated Disposal Facility Waste Performance Assessment*). The ROCSAN database contains data relating to particle size and calcium carbonate data. It does not contain contaminant data. Contaminant data from soil samples are contained in the HEIS database. A search for isotopic soil results only offered data for non-tank-farm regions. CH2M HILL Hanford Group, Inc. is currently drilling and analyzing soil samples from boreholes within the tank farms. However, sampling reports begin at a 16 to18 ft belowground surface depth, and are therefore not applicable.

Several RCRA groundwater monitoring wells were installed by Westinghouse Hanford Company at various single-shell tank farm Waste Management Areas during the late 1990s through the early 2000s in fulfillment of *Hanford Federal Facility Agreement and Consent Order - Tri-Party Agreement* (Ecology et al.) milestones. Most of the samples taken from the wells were analyzed for physical properties, such as soil moisture, sieve grain size, and geologic features. Sampling and well construction descriptions along with complete results are reported in Borehole Data Packages housed in the PNNL Library. The soil and geologic features assist in understanding surface soil conditions and in determining possibilities for constituent movement through the ground but are not valuable in establishing chemical constituents and contaminants.

In general, the soil generated from construction activities is returned to the work location from which it originated. Due to the various surface stabilization efforts performed within the farms, it is difficult to gather appropriate samples. When dealing with a specific spill, data detailing supernate and solids data found within the waste tanks can be found in the TWINS database. The "Hanford Site Near-Facility Environmental Monitoring Data Report" series that are generated by PNNL also contain some solid data for the tank farms (PNNL-13910-APP. 1, *Hanford Site Environmental Surveillance Data Report for Calendar Year 2001*). Individual waste container files containing data from which specific information may be extracted are accessed through the SWITS system. None of these data sources deals directly with data pertaining to the 15-ft layer of surface soil within the tank farms.

The TF database reports nonradiological and radiological data that were collected from samples gathered during waste removal resultant from accidental surface spills and debris. Metals including lead, chromium, and mercury and radionuclides like ^{137}Cs were detected and reported within the database. Before removal, the waste underwent a mandatory U.S. Environmental Protection Agency Method 1311, "Toxicity Characteristic Leaching Procedure" (TCLP). Because TCLP involves chemical alteration of any constituents present, translating ensuing TCLP data back into an environmental concentration proved impossible. Given the opportunistic nature of the data and its limited usability, the TF data are not considered a viable data source.

Given the lack of surface soil sampling, the data review process yielded little information regarding surface soil contamination. Cesium-137 was quantitatively determined from gamma logging data. It is considered an immobile contaminant and therefore acts as a marker for potential leaked or discharged contaminants (PNNL-14702, *Vadose Zone Hydrogeology Data Package for the 2004 Composite Analysis*). The gamma logging data provided quantitative measurements of near-surface contamination concentrations of ^{137}Cs. Cesium-137 measurements of 0.1, 1, 10, and 100 pCi/g are ubiquitous among the boreholes analyzed. These concentration values are utilized within this analysis to estimate the most general dose effects of contamination in the tank farms. However, in approximately 17% of the tank farms, gamma logging data reveals significantly higher concentrations of ^{137}Cs. These higher concentrations of ^{137}Cs are considered elevated regions. Using historical processing data outlined in Section 1, the ^{137}Cs elevated region measurements taken from gamma logging data were used to extrapolate a suite of contaminants present in various farm soils and associated with varied waste types.

For the almost four decades of active single-shell tank farm operations, the extensive waste transfers and reprocessing activities are well documented (WHC-MR-0132, *A History of the 200 Area Tank Farms*). The construction and operations of all of the single-shell tank farms are well documented, as are the compositions of various waste streams that were sent to the tank farms (RPP-19822). Thus, this extensive database can be used to project both the likely waste type and its composition. Because of cesium's propensity to sorb strongly on the soil particles, ^{137}Cs serves as a valid marker for past near-surface waste-loss events. Given a history of waste types lost to the soil column in the tank farms, the presence and activity of ^{137}Cs in the soil can be used to formulate a broad spectrum of radionuclide and metal concentrations by method of mathematical extrapolation. Relevant radionuclide activities and chemical concentrations can be selected from projected waste compositions to support the preliminary risk assessments.

A survey of spectral gamma logging data from all of the single-shell tank farms shows that the near-surface ^{137}Cs activity generally falls in the region of 0.1 to 100 pCi/g of soil. However, elevated regions exist where the ^{137}Cs activity falls in the range of 100,000 to 20 million pCi/g. For this assessment, the decision was made to have the results from this analysis reflect a worst-case scenario.

Hanford process chemistry and waste transfer records were tabulated in the Hanford Defined Waste (HDW) Model (RPP-19822). This document provided Excel[1] data tables for compositions of various process waste streams that were sent to the tank farms. The waste type composition includes 25 inorganic elements and 40 radionuclides. The approach used here was to ratio the ^{137}Cs activity (in μCi/g) found in the soil to the ^{137}Cs activity reported for the selected waste type. This ratio is then multiplied by each of the constituents listed in the HDW waste type composition.

[1] Excel is a registered trademark of the Microsoft Corporation, Redmond, Washington.

2.1 CONTAMINANT DECAY

It should be noted that the ^{137}Cs from spectral gamma logging is decayed to match the HDW model decay date of January 2001. The half-life for ^{137}Cs is equal to 30.17 years. Thus, utilizing the equation (*Nuclear and Radiochemistry*, Friedlander et al.)

$$N = N_0 e^{-(0.693t/T_{1/2})}$$

where

N is the activity
N_0 is the initial activity
e is the exponent function
t is the time of decay
$T_{1/2}$ is the half-life

the ^{137}Cs concentration as of January 2001 is derived.

2.2 ELEVATED REGION IDENTIFICATION

Outlined in Table 1 are the elevated regions evaluated in this assessment that were selected based on park ^{137}Cs levels and the ability to assign a specific waste type defined by HDW scaling. Included are the ^{137}Cs concentrations observed in the gamma logging data and the waste type scaled for individual farms.

Table 1. Assessment of Elevated Regions.

Tank Farm	Borehole Number	Cesium-137 Concentration (pCi/g)	Waste Type[a]
A Farm	10-01-03	9.37E+05	PUREX high-level waste
BX Farm	21-10-03	2.04E+07	BY saltcake supernate
C Farm	30-07-11	1.15E+05	B-Plant CSR waste
SX Farm	41-05-08	1.74E+05	REDOX-2 waste

[a] As defined in RPP-19822, Rev. 0.
CSR = supernate for cesium recovery process
PUREX = plutonium-uranium extraction
REDOX = reduction and oxidation

Elevated regions are presented by farm in alphabetical order with a description of the waste type scaled to determine radiological and nonradiological contaminant concentrations based on peak ^{137}Cs concentrations observed in each farm assessed.

2.3 DATA REVIEW RESULTS

The results of the data review are presented in Sections 2.3.1 through 2.3.4 for the four process waste types selected based on peak ^{137}Cs soil concentrations. Tables 2-3 through 2-5 are presented for the key contaminants in each section, respectively, based on those with the potential for greatest impact at 100 years using intruder scenarios as found in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*.

2.3.1 A Farm (Well 10-01-03) Plutonium-Uranium Extraction High-Level Waste

A-Plant operations were dominated by plutonium-uranium extraction (PUREX) processing from January 1956 through June 1972. A-Plant was shifted to standby mode until November 1983, when operations commenced and the PUREX process was used again until 1991. Wastes generated from 1983 to 1991 at A-Plant were dispatched to the double-shell tank farms. The PUREX process was a continuous solvent extraction process in which plutonium and uranium were separated from irradiated fuel rods using tributyl phosphate as the extractant and kerosene as a diluent (RPP-8847, *Best-Basis Inventory Template Compositions of Common Tank Waste Layers*). Wastes were highly radioactive and had a very high temperature.

Table 2 shows the concentrations of key A Farm contaminants. These concentrations were derived from the mathematical extrapolation process described in this document and based on a ^{137}Cs concentration value of 9.37E+05 pCi/g for the A Farm elevated region. A complete listing of concentrations of the full suite of contaminants scaled is in Appendix A.

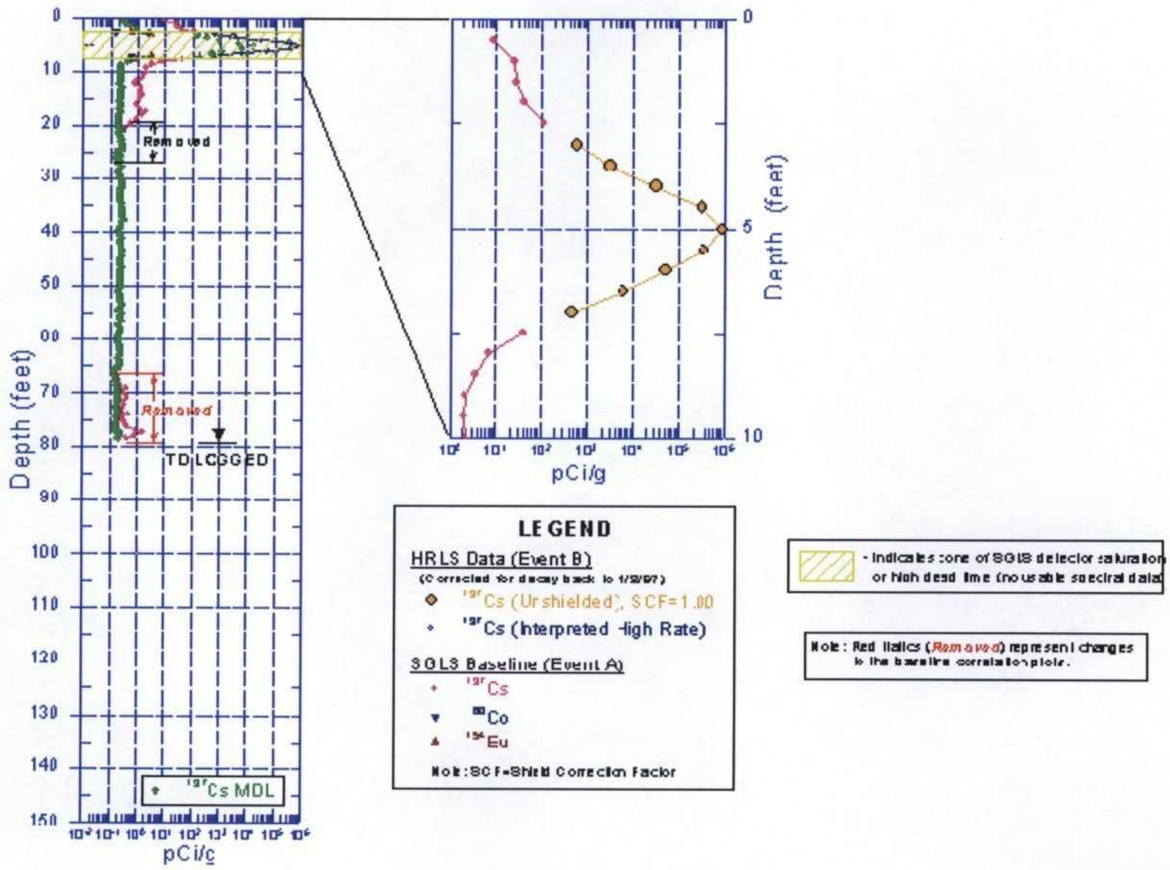
Table 2. A Farm Key Contaminants.[a]

A Farm PUREX H-L Waste (Well 10-01-03)	
Radionuclides	**pCi/g**
^{241}Am	2.22E+01
^{137}Cs	9.37E+05
^{237}Np	1.35E+00
^{239}Pu	1.68E+01
^{240}Pu	3.38E+00
^{241}Pu	1.48E+01
^{126}Sn	3.26E+00
^{90}Sr	8.18E+03

[a] The key contaminants are based on those with the potential for greatest impact at 100 years using intruder scenarios as found in DOE/ORP-2005-01.

The gamma logging data output for A Farm borehole 10-01-03 is shown in Figure 1. As noted in the graphic, the highest ^{137}Cs level observed in the top 15 ft of soil is about 9.37E+05 pCi/g.

Figure 1. A Farm, Well 10-01-03.



2.3.2 BX Farm (Well 21-10-03) Waste Type: BY Saltcake Supernate

B-Plant operations from 1960 through the early 1980s consisted primarily of ^{137}Cs and ^{90}Sr recovery. Initially these B-Plant waste streams were used to fill available tank space on B, BX, and BY tank farms. B-Plant wastes were comingled with PUREX low activity wastes and concentrated to saltcake using the BY in-tank solidification process (RPP-8847). BY Farm saltcake supernate waste was generated from in-tank solidification units used to remove liquid waste from the tanks from 1965 through 1974. The goal of liquid waste removal was to reduce the volume of waste within the tank farms. Electric and steam heaters were inserted into individual tanks to evaporate off the liquid waste. The salt that precipitated out of the liquid waste during this process was removed and transferred to a receiver tank. All byproducts were highly radioactive.

Table 3 shows the concentrations of key BX Farm contaminants. These concentrations were derived from the mathematical extrapolation process described in this document and based on a ^{137}Cs concentration value of 2.04E+07 pCi/g for the BX Farm elevated region. A complete listing of concentrations of contaminants scaled is in Appendix A.

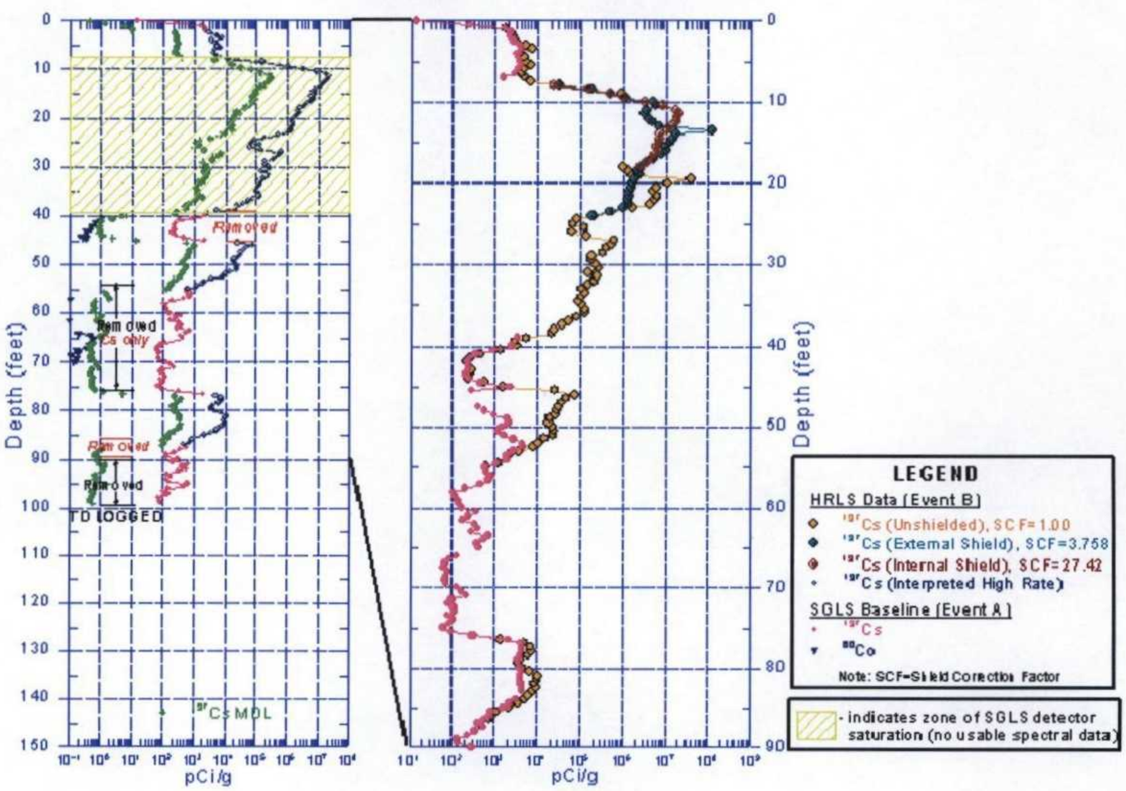
Table 3. BX Farm Key Contaminants.[a]

BY Saltcake Supernate (Well 21-10-03)	
Radionuclides	**pCi/g**
^{241}Am	8.37E+02
^{137}Cs	2.04E+07
^{237}Np	5.83E+01
^{239}Pu	6.27E+02
^{240}Pu	1.50E+02
^{241}Pu	1.41E+03
^{126}Sn	3.21E+02
^{90}Sr	3.08E+05

[a] The key contaminants are based on those with the potential for greatest impact at 100 years using intruder scenarios as found in DOE/ORP-2005-01.

Figure 2 shows the gamma logging data output for BX Farm borehole 21-10-03. As noted in Figure 2, the highest ^{137}Cs level observed in the top 15 ft of soil is 2.04E+07 pCi/g.

Figure 2. BX Farm, Well 21-10-03.



2.3.3 C Farm (Well 30-07-11 Waste Type: B Plant Supernate for Cesium Recovery Waste

C Plant was constructed as a pilot plant known as the Hot Semiworks or Strontium Semiworks and developed to support advancement of the reduction and oxidation (REDOX) and PUREX processes. Hot Semiworks primarily involved the recovery of ^{90}Sr from the varied waste streams. Given the propensity of ^{137}Cs to sorb to the soil, its gamma emitting property and the suspected leak time frame, B-Plant cesium-recovery waste appeared to be most appropriate to model for this assessment. Tank supernate was sent to B-Plant for ^{137}Cs recovery using tank 241-C-105 as a staging tank. From 1967 through 1976, 21,724 kgal of supernate were sent to and 26,290 kgal returned from B-Plant.

Table 4 shows the concentrations of key C Farm contaminants. These concentrations were derived from the mathematical extrapolation process described in this document and based on a ^{137}Cs concentration value of 1.15E+05 pCi/g for the C Farm elevated region. A complete listing of concentrations of the full suite of contaminants scaled is in Appendix A.

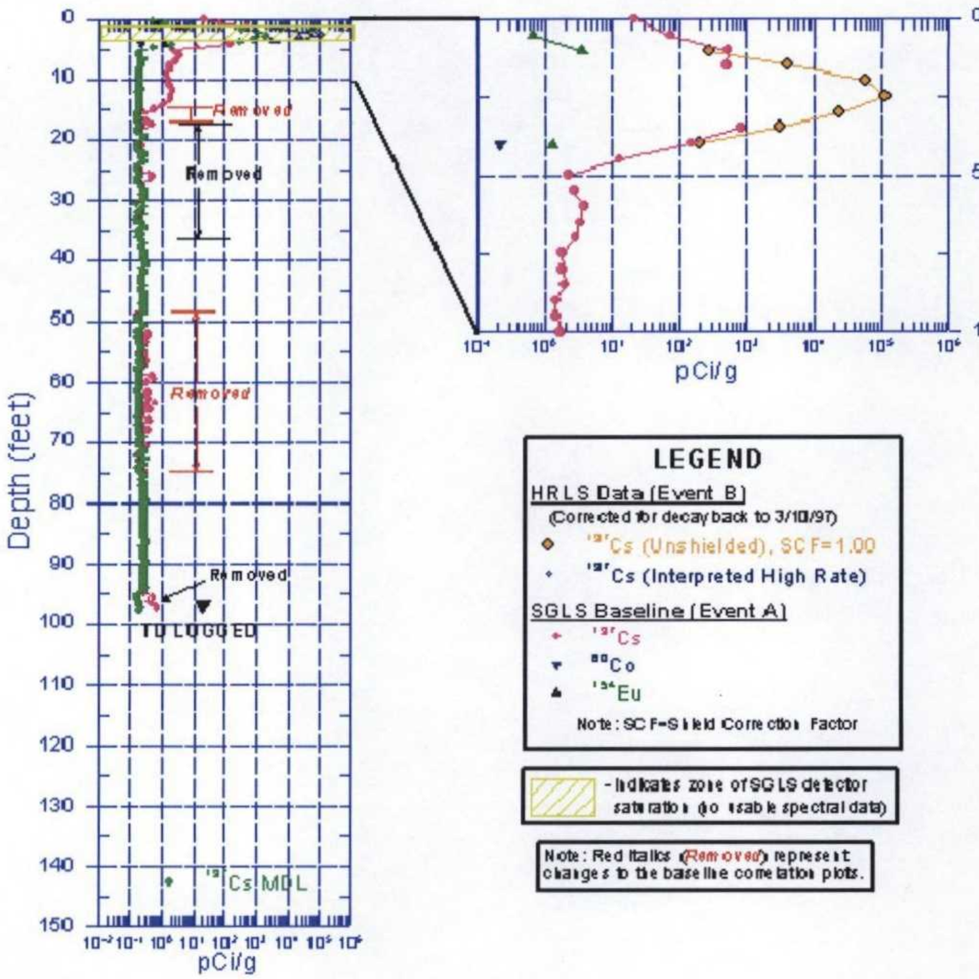
Table 4. C Farm Key Contaminants.[a]

C Farm B Plant CSR waste (Well 30-07-11)	
Radionuclides	**pCi/g**
^{241}Am	5.16E+01
^{137}Cs	1.15E+05
^{237}Np	3.59E+00
^{239}Pu	3.87E+01
^{240}Pu	8.96E+00
^{241}Pu	7.47E+01
^{126}Sn	1.43E+01
^{90}Sr	1.90E+04

[a] The key contaminants are based on those with the potential for greatest impact at 100 years using intruder scenarios as found in DOE/ORP-2005-01.

Figure 3 shows the gamma logging data output for C Farm borehole 30-07-11. As noted in the graphic, the highest ^{137}Cs level observed in the top 15 ft of soil is 1.15E+05 pCi/g.

Figure 3. C Farm, Well 30-07-11.



2.2.4 SX Farm (Well 41-05-08) Waste Type: Reduction and Oxidation Process-2 Waste

S-Plant operations involved reduction and oxidation (REDOX) processing from 1952 through 1966. REDOX-2 waste was created during the second phase of REDOX processing, which occurred between 1956 and 1958. REDOX was a continuous extraction process in which uranium and plutonium were extracted with a methylisobutylketone (hexone) solvent (RPP-8847). Wastes were highly radioactive and had a very high temperature.

Table 5 shows the concentrations of key SX Farm contaminants. These concentrations were derived from the mathematical extrapolation process described in this document and based on a ^{137}Cs concentration value of 1.74E+05 pCi/g for the SX Farm elevated region. A complete listing of concentrations of the full suite of contaminants scaled is in Appendix A.

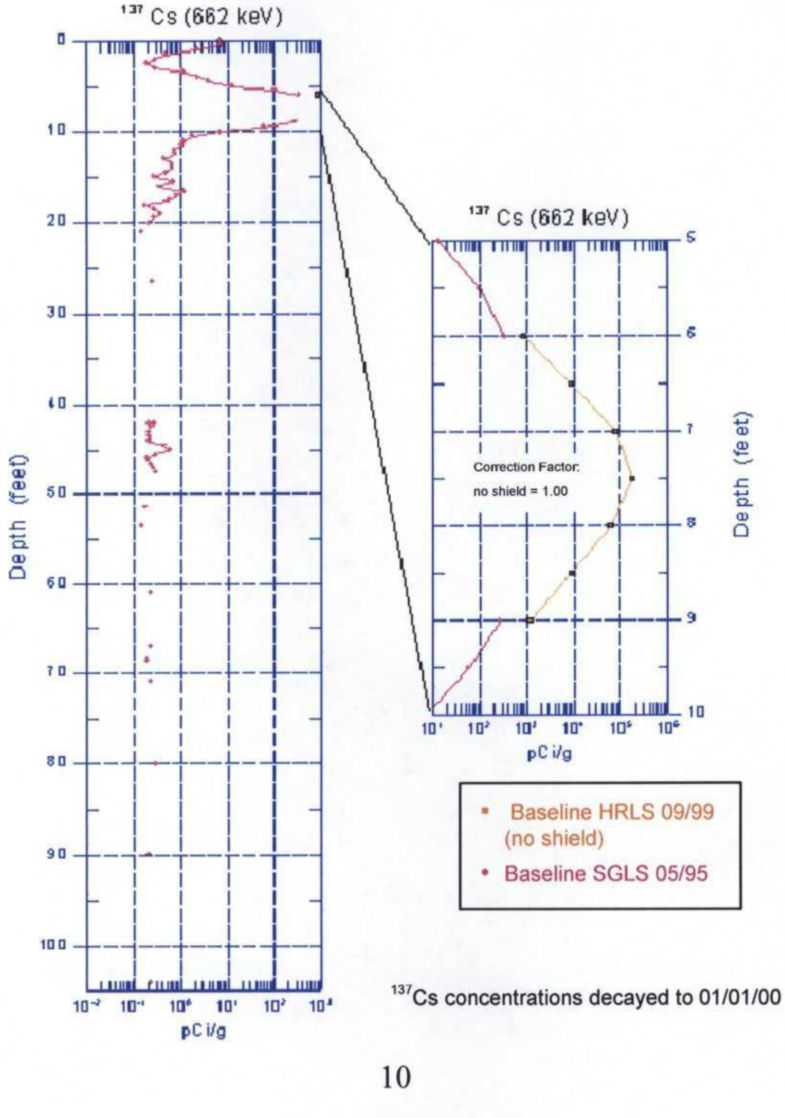
Table 5. SX Farm Key Contaminants.

SX Farm REDOX-2 (Well 41-05-08)	
Radionuclides	**pCi/g**
^{241}Am	4.36E+00
^{137}Cs	1.74E+05
^{237}Np	1.26E-01
^{239}Pu	3.27E+00
^{240}Pu	7.65E-01
^{241}Pu	5.80E+00
^{126}Sn	5.51E-01
^{90}Sr	1.61E+03

[a] The key contaminants are based on those with the potential for greatest impact at 100 years using intruder scenarios as found in DOE/ORP-2005-01.

Figure 4 shows the gamma logging data output for SX Farm borehole 41-05-08. As noted in Figure 4, the highest ^{137}Cs level observed in the top 15 ft of soil is 1.74E+05 pCi/g.

Figure 4. SX Farm, Well 41-05-08.



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APPENDIX A
CONTAMINANT SCALED DATA

A Farm Waste Type

PUREX H-L Waste (Well 10-01-03) List of HDW Rev 5 Chemical and Radioactive Contaminant Concentrations (3 Sheets)

Contaminant	HDW Rev 5 Concentration (chemical in µg/g/Radioactive in µCi/g)[a]	Scaled Concentration (chemical in µg/g/Radioactive in pCi/g)[b]
Na	1.61E+04	5.47E+01
Fe	1.01E+02	3.45E-01
Cr	4.05E+02	1.38E+00
Hg	3.14E-01	1.07E-03
Pb	2.25E+01	7.66E-02
Ni	1.04E+02	3.53E-01
Sr	4.41E-02	1.50E-04
Ca	1.46E+02	4.96E-01
K	1.20E+02	4.07E-01
OH	3.03E+03	1.03E+01
NO_3	1.05E+04	3.58E+01
NO_2	1.23E+04	4.19E+01
CO_3	2.18E+02	7.42E-01
SO_4	4.09E+03	1.39E+01
Si	2.87E+02	9.76E-01
Cl	4.99E+02	1.70E+00
NH_3	1.39E+02	4.73E-01
^{3}H (µCi/g)	3.77E-03	1.28E+01
^{14}C (µCi/g)	2.37E-03	8.06E+00
^{59}Ni (µCi/g)	5.94E-04	2.02E+00
^{63}Ni (µCi/g)	5.52E-02	1.88E+02
^{60}Co (µCi/g)	1.20E-02	4.07E+01
^{79}Se (µCi/g)	2.32E-04	7.89E-01
^{90}Sr (µCi/g)	2.40E+00	8.18E+03
^{90}Y (µCi/g)	2.40E+00	8.18E+03
^{93}Zr (µCi/g)	1.38E-02	4.70E+01
^{93m}Nb (µCi/g)	1.15E-02	3.91E+01
^{99}Tc (µCi/g)	7.27E-02	2.47E+02
^{106}Ru (µCi/g)	3.64E-09	1.24E-05

A Farm Waste Type

PUREX H-L Waste (Well 10-01-03) List of HDW Rev 5 Chemical and Radioactive Contaminant Concentrations (3 Sheets)

Contaminant	**HDW Rev 5 Concentration (chemical in µg/g/Radioactive in µCi/g)**[a]	**Scaled Concentration (chemical in µg/g/Radioactive in pCi/g)**[b]
^{113m}Cd (µCi/g)	1.22E-02	4.15E+01
^{125}Sb (µCi/g)	1.80E-03	6.14E+00
^{126}Sn (µCi/g)	9.58E-04	3.26E+00
^{129}I (µCi/g)	4.33E-06	1.47E-02
^{134}Cs (µCi/g)	6.85E-05	2.33E-01
^{137}Cs (µCi/g)	2.75E+02	9.37E+05
^{137m1}Ba (µCi/g)	2.60E+02	8.85E+05
^{151}Sm (µCi/g)	7.13E+00	2.42E+04
^{152}Eu (µCi/g)	1.06E-03	3.62E+00
^{154}Eu (µCi/g)	7.91E-02	2.69E+02
^{155}Eu (µCi/g)	3.61E-02	1.23E+02
^{226}Ra (µCi/g)	9.14E-09	3.11E-05
^{228}Ra (µCi/g)	5.62E-14	1.91E-10
^{227}Ac (µCi/g)	4.07E-08	1.39E-04
^{231}Pa (µCi/g)	5.80E-08	1.97E-04
^{229}Th (µCi/g)	1.52E-10	5.17E-07
^{232}Th (µCi/g)	5.79E-14	1.97E-10
^{232}U (µCi/g)	6.70E-10	2.28E-06
^{233}U (µCi/g)	4.72E-09	1.60E-05
^{234}U (µCi/g)	9.78E-06	3.33E-02
^{235}U (µCi/g)	4.18E-07	1.42E-03
^{236}U (µCi/g)	2.16E-07	7.35E-04
^{238}U (µCi/g)	1.00E-05	3.41E-02
U-Total (µg/g)	3.01E+01	1.02E+05
^{237}Np (µCi/g)	3.98E-04	1.35E+00
^{238}Pu (µCi/g)	1.22E-04	4.16E-01
^{239}Pu (µCi/g)	4.94E-03	1.68E+01
^{240}Pu (µCi/g)	9.93E-04	3.38E+00
^{241}Pu (µCi/g)	4.35E-03	1.48E+01
^{242}Pu (µCi/g)	3.10E-08	1.06E-04
Pu-Total (µg/g)	8.40E-02	2.86E+02
^{241}Am (µCi/g)	6.52E-03	2.22E+01

A Farm Waste Type

PUREX H-L Waste (Well 10-01-03) List of HDW Rev 5 Chemical and Radioactive Contaminant Concentrations (3 Sheets)

Contaminant	HDW Rev 5 Concentration (chemical in µg/g/Radioactive in µCi/g)[a]	Scaled Concentration (chemical in µg/g/Radioactive in pCi/g)[b]
^{243}Am (µCi/g)	3.00E-06	1.02E-02
^{242}Cm (µCi/g)	3.59E-05	1.22E-01
^{243}Cm (µCi/g)	7.02E-07	2.39E-03
^{244}Cm (µCi/g)	1.86E-05	6.33E-02

[a] Only HDW results for non-zero values of specific contaminants are included in this table.

[b] The scaled value is determined by calculating the ratio of the ^{137}Cs activity (in µCi/g) found in the soil to the ^{137}Cs activity reported for the selected waste type (ratio is 3.40E-03). Radioactive constituents are converted from µCi to pCi by multiplying by 1E+06.

BX Farm

BY Saltcake Supernate (Well 21-10-03) List of HDW Rev. 5 Chemical and Radioactive Contaminant Concentrations (3 Sheets)

Contaminant	HDW Rev 5 Concentration (Chemical in µg/g/Radioactive in µCi/g)[a]	Scaled Concentration (Chemical in µg/g/Radioactive in pCi/g[b]
Na	1.69E+05	3.17E+04
Al	3.13E+04	5.88E+03
Fe	6.95E+01	1.30E+01
Cr	1.91E+03	3.58E+02
Bi	2.25E+01	4.21E+00
La	1.63E-04	3.05E-05
Hg	2.15E-01	4.03E-02
Zr	3.68E+00	6.89E-01
Pb	9.89E+01	1.85E+01
Ni	7.10E+01	1.33E+01
Sr	1.02E-01	1.91E-02
Mn	2.02E+01	3.79E+00
Ca	9.97E+01	1.87E+01
K	1.67E+03	3.13E+02
OH	1.44E+04	2.70E+03
NO_3	1.44E+05	2.70E+04
NO_2	7.73E+04	1.45E+04
CO_3	2.10E+04	3.93E+03
PO_4	3.92E+03	7.36E+02
SO_4	7.90E+03	1.48E+03
Si	1.96E+02	3.68E+01
F	1.34E+03	2.50E+02
Cl	4.98E+03	9.34E+02
$C_6H_5O_7$	4.59E+03	8.61E+02
EDTA	5.44E+03	1.02E+03
HEDTA	6.83E+03	1.28E+03
Glycolate	1.87E+03	3.50E+02
Acetate	2.42E+03	4.53E+02
Oxalate	5.16E-01	9.68E-02
DBP	5.13E+03	9.62E+02
Butanol	1.81E+03	3.39E+02

BX Farm

BY Saltcake Supernate (Well 21-10-03) List of HDW Rev. 5 Chemical and Radioactive Contaminant Concentrations (3 Sheets)

Contaminant	HDW Rev 5 Concentration (Chemical in µg/g/Radioactive in µCi/g)[a]	Scaled Concentration (Chemical in µg/g/Radioactive in pCi/g[b]
NH_3	6.03E+02	1.13E+02
^{3}H (µCi/g)	5.13E-02	9.61E+03
^{14}C (µCi/g)	6.03E-03	1.13E+03
^{59}Ni (µCi/g)	2.63E-03	4.92E+02
^{63}Ni (µCi/g)	2.52E-01	4.72E+04
^{60}Co (µCi/g)	1.59E-02	2.98E+03
^{79}Se (µCi/g)	4.12E-04	7.73E+01
^{90}Sr (µCi/g)	1.65E+00	3.08E+05
^{90}Y (µCi/g)	1.65E+00	3.09E+05
^{93}Zr (µCi/g)	2.44E-02	4.58E+03
^{93m}Nb (µCi/g)	1.97E-02	3.68E+03
^{99}Tc (µCi/g)	1.31E-01	2.45E+02
^{106}Ru (µCi/g)	2.24E-11	4.19E-06
^{113m}Cd (µCi/g)	3.05E-02	5.72E+03
^{125}Sb (µCi/g)	1.87E-04	3.51E+01
^{126}Sn (µCi/g)	1.71E-03	3.21E+02
^{129}I (µCi/g)	1.86E-04	3.48E+01
^{134}Cs (µCi/g)	1.26E-04	2.35E+01
^{137}Cs (µCi/g)	1.09E+02	2.04E+07
^{137m}Ba (µCi/g)	1.03E+02	1.93E+07
^{151}Sm (µCi/g)	4.83E-01	9.05E+04
^{152}Eu (µCi/g)	9.50E-05	1.78E+01
^{154}Eu (µCi/g)	7.16E-03	1.34E+03
^{155}Eu (µCi/g)	3.43E-03	6.44E+02
^{226}Ra (µCi/g)	4.11E-08	7.71E-03
^{228}Ra (µCi/g)	4.97E-05	9.31E+00
^{227}Ac (µCi/g)	2.39E-07	4.48E-02
^{231}Pa (µCi/g)	1.56E-04	2.93E+01
^{229}Th (µCi/g)	3.87E-08	7.26E-03
^{232}Th (µCi/g)	1.48E-07	2.77E-02
^{232}U (µCi/g)	2.12E-06	3.97E-01
^{233}U (µCi/g)	1.28E-04	2.40E+01

BX Farm

BY Saltcake Supernate (Well 21-10-03) List of HDW Rev. 5 Chemical and Radioactive Contaminant Concentrations (3 Sheets)

Contaminant	HDW Rev 5 Concentration (Chemical in µg/g/Radioactive in µCi/g)[a]	Scaled Concentration (Chemical in µg/g/Radioactive in pCi/g[b]
^{234}U (µCi/g)	8.36E-06	1.57E+00
^{235}U (µCi/g)	3.11E-07	5.83E-02
^{236}U (µCi/g)	2.13E-07	3.99E-02
^{238}U (µCi/g)	6.85E-06	1.29E+00
U-Total (µg/g)	2.06E+01	3.86E+06
^{237}Np (µCi/g)	3.11E-04	5.83E+01
^{238}Pu (µCi/g)	1.32E-04	2.48E+01
^{239}Pu (µCi/g)	3.34E-03	6.27E+02
^{240}Pu (µCi/g)	8.01E-04	1.50E+02
^{241}Pu (µCi/g)	7.54E-03	1.41E+03
^{242}Pu (µCi/g)	6.12E-08	1.15E-02
Pu-Total (µg/g)	5.75E-02	1.08E+04
^{241}Am (µCi/g)	4.46E-03	8.37E+02
^{243}Am (µCi/g)	1.78E-06	3.34E-01
^{242}Cm (µCi/g)	1.46E-05	2.74E+00
^{243}Cm (µCi/g)	5.12E-07	9.59E-02
^{244}Cm (µCi/g)	1.27E-05	2.39E+00

[a] Only HDW results for nonzero values of specific contaminants are included in this table.

[b] The scaled value is determined by calculating the ratio of the ^{137}Cs activity (in µCi/g) found in the soil to the ^{137}Cs activity reported for the selected waste type (ratio is 1.88E-01). This ratio is then multiplied by each of the constituents listed in the HDW waste type composition. Radioactive constituents are converted from µCi to pCi by multiplying by 1E+06.

DBP = dibenzothiophene
EDTA = ethylenediaminetetraacetic acid
HEDTA = hydroxyethylethylenediaminetriacetate

C Farm

B Plant CSR Waste (Well 30-07-11) List of HDW Rev. 5 Chemical and Radioactive Contaminant Concentrations (3 Sheets)

Contaminant	HDW Rev 5 Concentration (Chemical in µg/g/Radioactive in µCi/g)[a]	Scaled Concentration (Chemical in µg/g/Radioactive in pCi/g)[b]
Na	8.01E+04	7.32E+02
Al	8.71E+03	7.96E+01
Fe	8.79E+01	8.03E-01
Cr	1.38E+03	1.26E+01
Bi	8.93E-01	8.15E-03
Hg	2.72E-01	2.49E-03
Zr	1.23E-01	1.12E-03
Pb	8.53E+01	7.79E-01
Ni	8.98E+01	8.21E-01
Sr	3.87E-02	3.54E-04
Mn	1.49E+01	1.36E-01
Ca	1.26E+02	1.15E+00
K	6.84E+02	6.25E+00
OH	1.42E+04	1.30E+02
NO_3	6.52E+04	5.96E+02
NO_2	3.32E+04	3.03E+02
CO_3	9.29E+03	8.49E+01
PO_4	5.15E+02	4.70E+00
SO_4	7.59E+03	6.93E+01
Si	2.48E+02	2.27E+00
F	2.61E+01	2.38E-01
Cl	2.09E+03	1.91E+01
$C_6H_5O_7$	4.37E+03	4.00E+01
EDTA	8.49E+02	7.76E+00
HEDTA	1.63E+03	1.48E+01
Glycolate	4.42E+02	4.04E+00
DBP	2.60E+03	2.38E+01
Butanol	9.17E+02	8.38E+00
NH_3	3.51E+02	3.21E+00
^{3}H (µCi/g)	1.65E-02	1.51E+02
^{14}C (µCi/g)	3.17E-03	2.90E+01
^{59}Ni (µCi/g)	5.89E-04	5.38E+00

C Farm

B Plant CSR Waste (Well 30-07-11) List of HDW Rev. 5 Chemical and Radioactive Contaminant Concentrations (3 Sheets)

Contaminant	**HDW Rev 5 Concentration (Chemical in µg/g/Radioactive in µCi/g)[a]**	**Scaled Concentration (Chemical in µg/g/Radioactive in pCi/g)[b]**
^{63}Ni (µCi/g)	5.60E-02	5.11E+02
^{60}Co (µCi/g)	2.01E-02	1.84E+02
^{79}Se (µCi/g)	3.78E-04	3.45E+00
^{90}Sr (µCi/g)	2.08E+00	1.90E+04
^{90}Y (µCi/g)	2.08E+00	1.90E+04
^{93}Zr (µCi/g)	2.25E-02	2.06E+02
^{93m}Nb (µCi/g)	1.82E-02	1.66E+02
^{99}Tc (µCi/g)	1.20E-01	1.10E+03
^{106}Ru (µCi/g)	3.40E-08	3.11E-04
^{113m}Cd (µCi/g)	2.35E-02	2.15E+02
^{125}Sb (µCi/g)	5.56E-03	5.08E+01
^{126}Sn (µCi/g)	1.57E-03	1.43E+01
^{129}I (µCi/g)	7.11E-05	6.50E-01
^{134}Cs (µCi/g)	1.02E-05	9.33E-02
^{137}Cs (µCi/g)	1.26E+01	1.15E+05
^{137m}Ba (µCi/g)	1.19E+01	1.09E+05
^{151}Sm (µCi/g)	4.96E+00	4.53E+04
^{152}Eu (µCi/g)	9.20E-04	8.40E+00
^{154}Eu (µCi/g)	6.85E-02	6.26E+02
^{155}Eu (µCi/g)	3.16E-02	2.89E+02
^{226}Ra (µCi/g)	1.76E-08	1.61E-04
^{228}Ra (µCi/g)	8.19E-07	7.49E-03
^{227}Ac (µCi/g)	1.04E-07	9.54E-04
^{231}Pa (µCi/g)	2.82E-07	2.58E-03
^{229}Th (µCi/g)	4.55E-09	4.16E-05
^{232}Th (µCi/g)	1.27E-08	1.16E-04
^{232}U (µCi/g)	2.18E-07	1.99E-03
^{233}U (µCi/g)	1.35E-05	1.23E-01
^{234}U (µCi/g)	9.26E-06	8.46E-02
^{235}U (µCi/g)	3.87E-07	3.53E-03
^{236}U (µCi/g)	2.51E-07	2.29E-03
^{238}U (µCi/g)	8.68E-06	7.93E-02
U-Total (µg/g)	2.60E+01	2.38E+05

C Farm

B Plant CSR Waste (Well 30-07-11) List of HDW Rev. 5 Chemical and Radioactive Contaminant Concentrations (3 Sheets)

Contaminant	HDW Rev 5 Concentration (Chemical in µg/g/Radioactive in µCi/g)[a]	Scaled Concentration (Chemical in µg/g/Radioactive in pCi/g)[b]
^{237}Np (µCi/g)	3.93E-04	3.59E+00
^{238}Pu (µCi/g)	1.81E-04	1.65E+00
^{239}Pu (µCi/g)	4.24E-03	3.87E+01
^{240}Pu (µCi/g)	9.81E-04	8.96E+00
^{241}Pu (µCi/g)	8.18E-03	7.47E+01
^{242}Pu (µCi/g)	6.73E-08	6.15E-04
Pu-Total (µg/g)	7.28E-02	6.65E+02
^{241}Am (µCi/g)	5.65E-03	5.16E+01
^{243}Am (µCi/g)	3.18E-06	2.91E-02
^{242}Cm (µCi/g)	2.12E-05	1.94E-01
^{243}Cm (µCi/g)	6.46E-07	5.90E-03
^{244}Cm (µCi/g)	1.61E-05	1.47E-01

[a] Only HDW results for non-zero values of specific contaminants are included in this table.

[b] The scaled value is determined by calculating the ratio of the ^{137}Cs activity (in µCi/g) found in the soil to the ^{137}Cs activity reported for the selected waste type (ratio is 9.14E-03). This ratio is then multiplied by each of the constituents listed in the HDW waste type composition. Radioactive constituents are converted from µCi to pCi by multiplying by 1E+06.

CSR = supernate for cesium recovery process.
DBP = dibenzothiophene
EDTA = ethylenediaminetetraacetic acid
HEDTA = hydroxyethylethylenediaminetriacetate

SX Farm

REDOX-2 (Well 41-05-08) List of HDW Rev. 5 Chemical and Radioactive Contaminant Concentrations (2 Sheets)

Contaminant	HDW Rev 5 Concentration (Chemical in µg/g/Radioactive in µCi/g)[a]	Scaled Concentration (Chemical in µg/g/Radioactive in pCi/g)[b]
Na	1.00E+05	8.12E+01
Al	2.15E+04	1.74E+01
Fe	8.38E+01	6.78E-02
Cr	2.31E+03	1.86E+00
Hg	2.60E-01	2.10E-04
Ni	8.57E+01	6.93E-02
Sr	3.86E-02	3.12E-05
Ca	1.20E+02	9.74E-02
K	6.33E+02	5.12E-01
OH	2.41E+04	1.95E+01
NO_3	6.45E+04	5.22E+01
NO2	5.18E+04	4.19E+01
CO_3	1.80E+02	1.46E-01
SO_4	2.33E+03	1.89E+00
Si	2.37E+02	1.92E-01
Cl	2.64E+03	2.13E+00
NH_3	5.00E+02	4.05E-01
^{3}H (µCi/g)	1.25E-01	1.01E+02
^{14}C (µCi/g)	7.80E-04	6.31E-01
^{59}Ni (µCi/g)	3.43E-04	2.77E-01
^{63}Ni (µCi/g)	3.24E-02	2.62E+01
^{60}Co (µCi/g)	1.08E-02	8.74E+00
^{79}Se (µCi/g)	1.69E-04	1.36E-01
^{90}Sr (µCi/g)	1.99E+00	1.61E+03
^{90}Y (µCi/g)	1.99E+00	1.61E+03
^{93}Zr (µCi/g)	1.01E-02	8.15E+00
^{93m}Nb (µCi/g)	8.12E-03	6.57E+00
^{99}Tc (µCi/g)	6.31E-02	5.11E+01
^{106}Ru (µCi/g)	3.00E-08	2.42E-05
^{113m}Cd (µCi/g)	1.00E-02	8.12E+00
^{125}Sb (µCi/g)	2.64E-03	2.14E+00
^{126}Sn (µCi/g)	6.82E-04	5.51E-01
^{129}I (µCi/g)	9.76E-05	7.90E-02
^{134}Cs (µCi/g)	2.25E-04	1.82E-01
Cs-137 (µCi/g)	2.15E+02	1.74E+05
^{137m}Ba (µCi/g)	2.03E+02	1.64E+05
^{151}Sm (µCi/g)	2.14E+00	1.73E+03

SX Farm

REDOX-2 (Well 41-05-08) List of HDW Rev. 5 Chemical and Radioactive Contaminant Concentrations (2 Sheets)

Contaminant	HDW Rev 5 Concentration (Chemical in µg/g/Radioactive in µCi/g)[a]	Scaled Concentration (Chemical in µg/g/Radioactive in pCi/g)[b]
^{152}Eu (µCi/g)	5.83E-04	4.71E-01
^{154}Eu (µCi/g)	3.87E-02	3.13E+01
^{155}Eu (µCi/g)	1.62E-02	1.31E+01
^{226}Ra (µCi/g)	1.03E-08	8.36E-06
^{228}Ra (µCi/g)	8.92E-14	7.21E-11
^{227}Ac (µCi/g)	4.28E-08	3.46E-05
^{231}Pa (µCi/g)	6.26E-08	5.06E-05
^{229}Th (µCi/g)	5.61E-11	4.53E-08
^{232}Th (µCi/g)	9.15E-14	7.40E-11
^{232}U (µCi/g)	9.03E-10	7.30E-07
^{233}U (µCi/g)	2.56E-09	2.07E-06
^{234}U (µCi/g)	1.18E-05	9.58E-03
^{235}U (µCi/g)	4.49E-07	3.63E-04
^{236}U (µCi/g)	3.42E-07	2.77E-04
^{238}U (µCi/g)	8.27E-06	6.69E-03
U-Total (µg/g)	2.48E+01	2.01E+04
^{237}Np (µCi/g)	1.55E-04	1.26E-01
^{238}Pu (µCi/g)	2.77E-04	2.24E-01
^{239}Pu (µCi/g)	4.04E-03	3.27E+00
^{240}Pu (µCi/g)	9.46E-04	7.65E-01
^{241}Pu (µCi/g)	7.17E-03	5.80E+00
^{242}Pu (µCi/g)	5.46E-08	4.42E-05
Pu-Total (µg/g)	6.94E-02	5.61E+01
^{241}Am (µCi/g)	5.39E-03	4.36E+00
^{243}Am (µCi/g)	4.66E-06	3.77E-03
^{242}Cm (µCi/g)	9.00E-06	7.28E-03
^{243}Cm (µCi/g)	6.98E-07	5.64E-04
^{244}Cm (µCi/g)	1.54E-05	1.24E-02

[a] Only HDW results for non-zero values of specific contaminants are included in this table.

[b] The scaled value is determined by calculating the ratio of the ^{137}Cs activity (in µCi/g) found in the soil to the ^{137}Cs activity reported for the selected waste type (ratio is 8.09E-04). This ratio is then multiplied by each of the constituents listed in the HDW waste type composition. Radioactive constituents are converted from µCi to pCi by multiplying by 1E+06.