S

CH2M HILL ENGINEERING CHANGE NOTICE

Page 1 of 2 ☒ DM ☐ FM ☐ TM

1a. ECN 722118 R 0

1b. Proj. ECN - - R

2. Simple Modification ☒ Yes ☐ No	3. Design Inputs – For full ECNs, record information on the ECN-1 Form (not required for Simple Modifications)		4. Date 9-21-04
5. Originator's Name, Organization, MSIN, & Phone No. D. H. Shuford, Projects, T4-67, 372-0703		6. USQ Number No. - - - R - ☒ N/A	7. Related ECNs N/A
8. Title Tank S-109 Long-Term Human Health Risk Calculations	9. Bldg. / Facility No. S-109/241-S	10. Equipment / Component ID S-109 Series Tank	11. Approval Designator N/A
12. Engineering Documents/Drawings to be Changed (Incl. Sheet & Rev. Nos.) RPP-19136, Rev. 0		13. Safety Designation ☐ SC ☐ SS ☐ GS ☒ N/A	14. Expedited/Off-Shift ECN? ☐ Yes ☒ No
15a. Work Package Number N/A	15b. Modification Work Completed N/A Responsible Engineer / Date	15c. Restored to Original Status (TM) N/A Responsible Engineer / Date	16. Fabrication Support ECN? ☐ Yes ☒ No

17. **Description of the Change** (Use ECN Continuation pages as needed)

Problem: This document " Tank S-109 Long-Term Health Risk Calculations" (RPP-19136, Rev. 0) was produced to support the "S-109 Partial Waste Retrieval Functions and Requirements" document RPP-18812 (Revisions 0 & 1) that was submitted to WDOE for review and comment. This process resulted in comments and required changes in the F&R; it is now necessary to change RPP-19136 to continue to support RPP-18812, Rev. 2 (with the required WDOE modifications included).

Solution: This direct revision of RPP-19136, Rev. 0, "Tank S-109 Long-Term Health Risk Calculations" to produce RPP-19136, Revision 1, will provide the changes needed for these calculations to continue to support the S-109 F&R (RPP-18812, Rev. 2).

Analysis: N/A

Scope: Modify RPP-19136 as described.

18. **Justification of the Change** (Use ECN Continuation pages as needed)

This calculation document was originally prepared to support the S-109 F&R (RPP-18812 Rev. 0 & 1); as a "primary agreement document", the F&R was submitted to the Washington Department of Ecology (WDOE) for review. The WDOE review or the F&R required changes in that document; to support those changes, it is necessary to revise the calculation document (RPP-19136) as described in Block 17.

USQ evaluation is not required (Block 6) as this document does not directly change field configuration or implement field operating requirements.

19. **ECN Category**

☒ Direct Revision
☐ Supplemental
☐ Void/Cancel

ECN Type

☐ Supercedure
☐ Revision

20. **Distribution**

Name	MSIN	Name	MSIN
See Attached Distribution Sheet.			

Release Stamp

SEP 23 2004
DATE:
STA: 4
HANFORD RELEASE
ID: 21

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1a. ECN 722118 R 0

1b. Proj. ECN - - R

21. **Revisions Planned** (Include a brief description of the contents of each revision)

None

Note: All revisions shall have the approvals of the affected organizations as identified in block 11 "Approval Designator," on page 1 of this ECN.

22. **Design Basis Documents**

☒ Yes ☐ No

23. **Commercial Grade Item Dedication Numbers** (associated with this design change)

N/A

24. **Engineering Data Transmittal Numbers** (associated with this design change, e.g., new drawings, new documents)

N/A

25. **Other Non Engineering (not in HDCS)documents that need to be modified due to this change**

Type of Document	Document Number	Type of Document	Document Number
None			

26. **Field Change Notice(s) Used?**

☐ Yes ☒ No

If Yes, Record Information on the ECN-2 Form, attach form(s), include a description of the interim resolution on ECN Page 1, block 17, and identify permanent changes.

NOTE: ECNs are required to record and approve all FCNs issued. If the FCNs have not changed the original design media then they are just incorporated into the design media via an ECN. If the FCN did change the original design media then the ECN will include the necessary engineering changes to the original design media.

27. **Design Verification Required?**

☐ Yes ☒ No

If Yes, as a minimum attach the one page checklist from TFC-ENG-DESIGN-P-17.

28. **Approvals**

Facility/Project Signatures		Date	A/E Signatures		Date
Design Authority	GP Janicek	9/23/04	Originator/Design Agent		
Resp. Engineer	DH Shuford	9/23/04	Professional Engineer		
Resp. Manager	WT Thompson	9/22/04	Project Engineer		
Quality Assurance			Quality Assurance		
IS&H Engineer			Safety		
NS&L Engineer			Designer		
Environ. Engineer	CJ Kemp	9-23-04	Environ. Engineer		
Engineering Checker	SE Carlson	9/22/04	Other		
Other			Other		
Other			DEPARTMENT OF ENERGY / OFFICE OF RIVER PROTECTION		
Other			Signature or a Control Number that tracks the Approval Signature		
Other					
Other			ADDITIONAL SIGNATURES		
Other					
Other					

DISTRIBUTION SHEET

To Distribution	From SST Projects	Page 1 of 1
Project Title/Work Order Tank S-109 Long-Term Human Health Risk Calculations		**Date** September 2004 **EDT No.** NA **ECN No.** 722118 R0

Name	MSIN	Text With All Attach.	Text Only	Attach/ Appendix Only	EDT/ECN Only
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^EQRG	R1-14	X			
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S-109 Long-Term Human Health Risk Calculations

D. H. Shuford
CH2M HILL Hanford Group, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-99RL14047

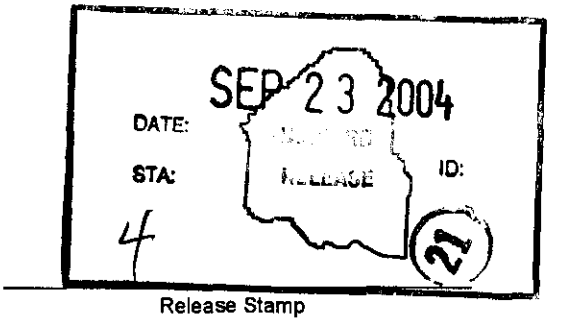
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Key Words: S-109, S Farm, S-109 Partial Waste Retrieval Project, S-109 Risk Calculation (Calc. No. S-109 R&R-001) in support of F&R Document, Tri-Party Agreement, TPA.

Abstract: This document provides Tank S-109 long-term human risks calculations, in support of Functions and Requirements document (RPP-18812) as required by Milestone M-45-00 of the Hanford Federal Facility Agreement and Consent Order.

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9/23/04
Release Approval Date

Release Stamp

Approved For Public Release

RECORD OF REVISION

(1) Document Number: RPP-19136

(2) Title: Tank S-109 Long-Term Human Health Risk Calculations

Change Control Record

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) Tank S-109 Long-Term Human Health Risk Calculations - Initial Release	D. Shuford	W.T. Thompson
1 RS	Incorporates WDOE comments, per ECN 722118 R0	D. Shuford 9/21/04	W.T. Thompson 9/21/04

Calculation Cover Sheet

Calculation No.: **S-109F&R-001**	Calculation Title: **Tank S-109 Long-Term Human Health Risk Calculations**
Revision No.: **1**	
Project No.: **CHG 21692/Rel2**	Project Title **Tank S-109 Waste Retrieval Functions and Requirements**

Original and Revised Calculation/Analysis Approval

	Rev. 0 Name/Signature/Date	Rev. 1 Name/Signature/Date	Rev. _____ Name/Signature/Date
Originator:	Signature on original	Doug Evans 6/29/2004	
Checked by:	Signature on original	Dwayne Crumpler 6/29/04	
Approved by:			
Other:			

Record of Revision

Revision	Reason for Revision
0	Initial release of RPP-19136. Supported initial release of RPP-18812.
1	Analysis revised in response to Ecology comments: 1) expanded screening procedure to include toxic chemicals and carcinogenic chemicals, in addition to radionuclides, 2) used different screening criterion (actual rather than surrogate risk values) in the screening procedure, and 3) used different groundwater concentration values to calculate transfer functions (used three-dimensional values from RPP-7884, Table G.3 rather than two-dimensional values from RPP-7884, Table E.14, for consistency with RPP-7884 risk analysis).

Affected Documents

Document Number	Document Title	Revision Number
RPP-18812	Tank S-109 Waste Retrieval Functions and Requirements	Rev. 1

Calculation Sheet

Calculation No.:	Rev.:	Title:
S-109F&R-001	1	**Tank S-109 Long-Term Human Health Risk Calculations**

Project No.:	Title:
CHG 21692/Rel2	**Tank S-109 Waste Retrieval Functions and Requirements**

Originated by:	Checked by:
Date: 6/29/2004	Date: 6/29/04
Doug Evans	Dwayne Crumpler

1.0 INTRODUCTION

This calculation was performed to provide a screening-level assessment of long-term human health risk associated with potential leakage that could occur during tank S-109 partial waste retrieval operations in support of a planned treatment demonstration. This calculation supports the development of tank S-109 partial waste retrieval functions and requirements as documented in RPP-18812.

Evaluation of the risk associated with the current waste and potential residual waste in tank S-109, as well as the risk associated with the other S farm tanks, were not included in the evaluation. Evaluation of those risks is deferred to the analysis supporting final tank S-109 waste retrieval.

2.0 CALCULATION METHODOLOGY AND ASSUMPTIONS

The evaluation methodology and assumptions can be summarized as follows:

- Focused on potential long-term groundwater pathway human health risk at the tank farm fenceline
- Used incremental lifetime cancer risk (ILCR) and hazard index (HI) as the risk metrics
- Provided radiological ILCR for one indicator contaminant
- Provided noncarcinogenic chemical HI for one indicator contaminant
- Derived effects of contaminant release and transport from previous studies; involved no new contaminant transport analysis
- Used existing data and information, with little new data generated for the creation of the document.

Risk impacts were calculated using the following equation.

$$Ri = Ii \times Ti \times Hi \qquad \text{(Equation 1)}$$

Where:

i = indicator contaminant
Ri = risk metric (radiological ILCR or noncarcinogenic chemical HI)
Ii = inventory (Ci or kg released into the environment from leakage during retrieval)
Ti = transport transfer function (pCi/L per Ci or mg/L per kg)
Hi = health effects conversion factor (ILCR per pCi/L or HI per mg/L)

3.0 CALCULATION

All calculations were performed on an Excel spreadsheet. Calculation summary descriptions are provided in the following subsections. Calculation details are shown on the attached spreadsheet printouts.

Calculation No.: S-109F&R-001	Rev.: 1	Title: Tank S-109 Long-Term Human Health Risk Calculations
Project No.: CHG 21692/Rel2	Title: Tank S-109 Waste Retrieval Functions and Requirements	
Originated by: Date: 6/29/2004 Doug Evans		Checked by: Date: 6/29/04 Dwayne Crumpler

3.1 Indicator Contaminant Screening

The evaluation used the human health impacts from indicator contaminants rather than the total human health impacts from all contaminants. This approach was adopted to ensure that the resulting graphical tool would be sufficiently simple to facilitate rapid decision making during waste retrieval.

The indicator contaminants were the contaminants estimated to make the largest contribution to the total human health impacts. Contaminant screening was performed to identify the indicator contaminant for each metric used. The primary metrics were radiological ILCR and noncarcinogenic chemical HI. Nonradiological ILCR was also included for informational purposes but was not carried forward as a separate evaluation metric (i.e., was not used to develop a graphical tool).

The screening procedure involved estimating contaminant-specific contributions to the total impact from a hypothetical 8,000-gallon retrieval leak from tank S-109. Contaminant-specific impacts were calculated using Equation 1 as the product of the estimated leak inventory (see Section 3.2), the health effects conversion factor (see Section 3.3), and the transport transfer function (see Section 3.4). The contaminant-specific impacts were then summed to give the total impact for each metric (see "Indicator Screen" on attached Excel calculation spreadsheet).

Contaminants included in the screening procedure were the mobile long-lived contaminants of concern that previous studies (e.g., RPP-7825, RPP-7884, RPP-10098, DOE/RL-98-72) have shown are significant contributors to peak long-term groundwater pathway impacts at the tank farm fenceline (see "Indicator Screen" on attached Excel calculation spreadsheet).

Technetium-99 was identified as the radiological ILCR indicator contaminant, based on a contribution of approximately 81% (industrial scenario) to 94% (residential scenario) of the total radiological ILCR for tank S-109 (see "Indicator Screen" on attached Excel calculation spreadsheet)

Nitrite was identified as the noncarcinogenic chemical HI indicator contaminant, based on a contribution of approximately 65% (industrial scenario) to 66% (residential scenario) of the total noncarcinogenic chemical HI (see "Indicator Screen" on attached Excel calculation spreadsheet).

Hexavalent chromium was evaluated for nonradiological ILCR for information purposes to provide an indication of the potential magnitude of that impact metric for tank S-109 (see "Indicator Screen" on attached Excel calculation spreadsheet).

3.2 Retrieval Leak Inventory

Potential tank S-109 retrieval leak contaminant inventories were calculated based on the data and recommendations in the Tank Closure EIS inventory data package (DOE/ORP-2003-02).

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Originated by: Date: 6/29/2004 Doug Evans		Checked by: Date: 6/29/04 Dwayne Crumpler

That document provides estimates of contaminant inventories associated with potential residual waste but not potential retrieval leaks. Section 6.4.2 of that document recommends that contaminant inventories associated with potential retrieval leaks be calculated by assuming that the contaminant concentrations in fluids leaked during retrieval would be the same as the contaminant concentrations in the final residuals remaining in the tank after retrieval. Accordingly, tank S-109 retrieval leak fluid was assumed to have the same waste composition as the final tank residuals given in DOE/ORP-2003-02, Table A.2 (see "Residual Inventory" on attached Excel calculation spreadsheet).

DOE/ORP-2003-02, Table A.2 provides estimated inventories associated with potential residual waste volumes of 360 cubic feet (2,700 gallons). Different inventory data sets are given for different assumed retrieval methods. For conservatism, the value used was taken from either the Selected Phase Retention data set (representative of dry retrieval methods) or the Hanford Tank Waste Operation Simulator modeling data set (representative of fluid-based retrieval methods), which ever was larger (see "Residual Inventory" on attached Excel calculation spreadsheet).

The tank S-109 retrieval leak fluid concentrations were calculated by dividing the Table A.2 residual inventory values by the residual waste volume of 2,700 gallons (see "Leak Inventory" on attached Excel calculation spreadsheet). The retrieval leak inventories were then calculated as the product of the retrieval leak fluid concentrations and the assumed retrieval leak volume.

A retrieval leak volume of 8,000 gal was used for informational purposes to provide a point of reference on the graphs. Retrieval leak inventories were calculated for all contaminants included in the screening procedure. Chromium inventories were assumed to be entirely hexavalent chromium.

3.3 Transport Transfer Function

Contaminant transport calculations were not performed. Rather, the effects of contaminant release and transport were taken from the previous analysis that was the most relevant to the case being studied. For tank S-109, this was the vadose zone field investigation work for Waste Management Area S-SX (RPP-7884). That study involved numerical simulations of contaminant fate and transport for the existing S tank farm vadose zone contamination (past waste releases). The period of analysis for the numerical simulations was 1,000 years.

For the tank S-109 evaluation, proportionality coefficients called transport transfer functions were derived from the RPP-7884 analysis results and used in lieu of performing additional contaminant transport calculations. The transfer functions were calculated from the RPP-7884 base case analysis results by dividing the simulated peak contaminant concentrations in groundwater at the S tank farm fenceline by the respective contaminant inventories released at the source (see "Transfer Functions" on attached Excel calculation spreadsheet).

The transfer functions were used to represent the unit contaminant concentrations in groundwater per unit inventory released at the source (pCi/L per Ci for radionuclides, mg/L per kg for chemicals). The product of the transfer function and the contaminant inventory gives an estimate of peak contaminant concentration in groundwater. Transfer functions were applied to the ILCR and HI calculations as shown in Equation 1.

The transfer functions derived from the RPP-7884 analysis results were considered appropriate for use in estimating groundwater impacts from ex-tank waste (past leaks, potential retrieval leaks). These transfer functions would not be appropriate for use with in-tank waste (tank and ancillary equipment). Transfer functions for in-tank waste were not needed for this evaluation and were not developed.

The RPP-7884 base case simulation results indicated the peak groundwater contaminant concentrations would arrive at the S tank farm fence line in approximately the year 2046. The arrival time of the peak groundwater concentrations and associated human health impacts calculated using these transfer functions (Equation 1) is therefore also approximately in the year 2046.

Three mobile contaminants of concern (technetium-99, hexavalent chromium, and nitrate) were directly included in the RPP-7884 numerical simulations. Transfer functions were calculated for each of these contaminants (see "Transfer Functions" on attached Excel calculation spreadsheet).

Because the RPP-7884 analysis results did not allow transfer functions to be calculated for all contaminants included in the screening procedure, contaminants were grouped for purposes of this evaluation based similarities in subsurface transport behavior. The technetium-99 transfer function was used for technetium-99 and the other radionuclides included in the screening procedure. Likewise, the nitrate transfer function was used for both nitrate and nitrite. The chromium transfer function was used only for chromium. The nitrate transfer function was used for nitrite instead of the hexavalent chromium transfer function because it is larger and therefore provides a more conservative impact estimate (see "Transfer Functions" on attached Excel calculation spreadsheet).

3.4 Health Effects Conversion Factors

Health effects conversion factors were taken directly from tables in HNF-SD-WM-TI-707. The factors used were for exposures via the groundwater pathway. Factors for two exposure scenarios, industrial and residential, were used (see "Risk Factors" on attached Excel calculation spreadsheet).

The health effects conversion factors represent the human health effects per unit contaminant concentration in groundwater (ILCR per pCi/L for radionuclides, HI per mg/L for noncarcinogenic chemicals). The product of the health effects conversion factors and the projected peak

groundwater concentrations was used to provide an estimate of the peak human health impacts (ILCR or HI) (see Equation 1).

4.0 RESULTS

Results were calculated and presented on two separate graphs, one for each indicator contaminant (technetium-99, nitrite). Each graph shows peak groundwater pathway human health impacts at the S tank farm fenceline as a function of the amount of indicator contaminant leaked from tank S-109 during retrieval (see "Tc99 Plot" and "NO2 Plot" on attached Excel calculation spreadsheet).

Two sloped lines representing the industrial and residential scenarios were plotted on each graph. The data points for these lines were calculated by applying Equation 1 over a range of technetium-99 and nitrite inventory values for the industrial and residential scenarios. Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end (see "Tc99 Plot" and "NO2 Plot" on attached Excel calculation spreadsheet).

A vertical dashed line was added to each graph as a reference point to show the estimated technetium-99 and nitrite inventory associated with a potential tank S-109 retrieval leak of 8,000 gallons. These graphs are intended to serve as tools to aid operational decisions during retrieval. In the event a leak is detected during retrieval, the potential impacts from leak volumes greater or lesser than the 8,000-gallon reference volume can be estimated rapidly by extrapolation from the impacts shown for the reference volume.

5.0 REFERENCES

DOE/RL-98-72, 1999, *Retrieval Performance Evaluation Methodology for the AX Tank Farm*, Rev. 0, U.S. Department of Energy, Richland, Washington.

DOE/ORP-2003-02, 2003, *Inventory and Source Term Data Package*, Rev. 0, U.S. Department of Energy, Richland, Washington.

HNF-SD-WM-TI-707, 2003, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment*, Rev. 3, U.S. Department of Energy, Richland, Washington.

RPP-7825, 2002, *Single-Shell Tank S-112 Full Scale Saltcake Waste Retrieval Technology Demonstration Functions and Requirements*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-7884, 2002, *Field Investigation Report for Waste Management Area S-SX*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-10098, 2002, *Field Investigation Report for Waste Management Area B-BX-BY*, Rev. 0, CH2M

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Project No.: CHG 21692/Rel2	Title: **Tank S-109 Waste Retrieval Functions and Requirements**	
Originated by: Date: DR 6/29/2004 Doug Evans		Checked by: Date: 6/29/04 Dwayne Crumpler

HILL Hanford Group, Inc., Richland, Washington.

RPP-18812, 2004, *Tank S-109 Waste Retrieval Functions and Requirements*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington. (January 2004)

Indicator Screen

Tank S-109 long-term human health risk impacts are evaluated using indicator contaminant impacts rather than total impacts from all contaminants. An indicator contaminant is the contaminant estimated to make the largest contribution to the total impact. Screening is performed to identify an indicator contaminant for each of the primary impact metrics used (radiological ILCR and noncarcinogenic chemical hazard index). Screening for nonradiological ILCR is also performed for informational purposes. The screening procedure involves estimating contaminant-specific contributions to the total estimated impact from a hypothetical 8,000 gallon retrieval leak from tank S-109. Contaminants included in the screening procedure are the mobile long-lived contaminants of concern that previous studies have shown contribute to peak long-term groundwater pathway impacts at the tank farm fenceline.

Contaminant-specific impacts are calculated as the product of the estimated leak inventory, the health effects conversion factor, and the ex-tank transport transfer function. Values for those three terms are called from other sheets in this workbook (Leak Inventory, Risk Factors, Transfer Functions). Contaminant-specific ex-tank transfer functions are not available for every contaminant in the screening procedure. The RPP-7884 analysis only provides data to calculate transfer functions for technetium-99, chromium, and nitrate (see Transfer Functions sheet). The screening procedure uses the technetium-99 transfer function for technetium-99 as well as the other radionuclides, the nitrate transfer function for both nitrate and nitrite, and the chromium transfer function for chromium. This is considered a reasonable approach because the contaminants being screened are all typically treated as having high subsurface mobility (i.e., all are simulated with distribution coefficients equal to 0 mL/g).

Radiological ILCR

Tank S-109 Mobile Long-Lived Radionuclide Contaminant of Concern Percentage Contributions to Total Radiological Incremental Lifetime Cancer Risk

Contaminant of Concern	Inventory in 8,000 gal Retrieval Leak[a]		Peak Incremental Lifetime Cancer Risk		Percentage of Total ILCR	
	Units	Tank S-109	Industrial	Residential	Industrial	Residential
C-14	Ci	2.96E-01	6.44E-05	4.65E-04	9.53	3.28
Se-79	Ci	3.96E-03	4.04E-06	2.08E-05	0.60	0.15
Tc-99	Ci	1.42E+00	5.50E-04	1.34E-02	81.44	94.49
I-129	Ci	2.74E-03	5.69E-05	2.95E-04	8.43	2.08
Total			6.75E-04	1.42E-02	100.00	100.00

[a]Called from Leak Inventory sheet in this workbook

Noncarcinogenic Chemical Hazard Index

Tank S-109 Mobile Noncarcinogenic Chemical Contaminant of Concern Percentage Contributions to Total Hazard Index

Contaminant of Concern	Inventory in 8,000 gal Retrieval Leak[a]		Peak Hazard Index		Percentage of Total Hazard Index	
	Units	Tank S-109	Industrial	Residential	Industrial	Residential
nitrate	kg	8.70E+03	2.10	13.53	17.32	17.77
nitrite	kg	2.03E+03	7.86	50.58	64.83	66.42
chromium VI[b]	kg	1.77E+02	2.17	12.03	17.85	15.80
Total			1.21E+01	7.61E+01	100.00	100.00

[a]Called from Leak Inventory sheet in this workbook

[b]Reported chromium inventory conservatievly assumed to be entirely hexavalent chromium

Nonradiological Cancer Risk

In addition to radionuclides and noncarcinogenic chemicals, tank waste is also known to contain carcinogenic chemicals. Cancer risks from radionuclides and carcinogenic chemicals are typically reported as separate metrics rather than being summed because of differences in how risk is estimated for these two categories of substances. A total of 24 nonradiological chemical contaminants are included in the BBI. Of these, only one, hexavalent chromium, has a published cancer slope factor. Hexavalent chromium ILCR is included in this screening procudure for informational purposes to provide an indication of the potential magnitude of the nonradiological ILCR for tank S-109.

Because it is based on only one contaminant, nonradiological ILCR is not carried forward as a separate evaluation metric. Hexavalent chromium is classified as both a chemical toxicant and a carcinogen. It is toxic via ingestion and inhalation but carcinogenic only via inhalation. The inhalation intake for the groundwater pathway exposures is based on resuspended soil and volatilized water (HNF-SD-WM-TI-707). The soil is assumed to be contaminated by irrigation with contaminated groundwater. Water volatilization is assumed to occur during showering.

Tank S-109 Mobile Carcinogenic Chemical Contaminant of Concern Percentage Contributions to Total Nonradiolgical Cancer Risk

Contaminant of Concern	Inventory in 8,000 gal Retrieval Leak[a]		Peak Cancer Risk		Percentage of Total Cancer Risk	
	Units	Tank S-109	Industrial	Residential	Industrial	Residential
chromium VI	kg	1.77E+02	1.35E-05	3.01E-05	100.00	100.00
Total			1.35E-05	3.01E-05	100.00	100.00

[a]Called from Leak Inventory sheet in this workbook

[b]Reported chromium inventory conservatievly assumed to be entirely hexavalent chromium

Residual Inventory

Modified from Table A.2, DOE/RL-2003-02, *Inventory and Source Term Data Package* (April 2003)

SUMMARY OF FINAL INVENTORY ESTIMATES
Based on 10.2 kL (360 ft3) remaining (30 ft3 in 200 series tanks)

Tank	Current Tank Radionuclide Inventory Based on BBI (Ci)	Current Tank Chemical Inventory Based on BBI (kg)	Estimate at Closure Based on selected phase Retention								
			Total Ci	Total kg	129I	14C	79Se	99Tc	Cr	NO2	NO3
241-S-109	2.45E+05	2.68E+06	2.17E+04	7.81E+03	3.18E-04	2.37E-02	5.04E-04	1.66E-01	5.97E+01	6.87E+02	1.87E+03

Tank	Current Tank Radionuclide Inventory Based on BBI (Ci)	Current Tank Chemical Inventory Based on BBI (kg)	Estimate at Closure Based on HTWOS Modeling								
			Total Ci	Total kg	129I	14C	79Se	99Tc	Cr	NO2	NO3
241-S-109	2.45E+05	2.68E+06	3.75E+02	4.41E+03	9.25E-04	9.99E-02	1.34E-03	4.81E-01	8.24E+00	3.56E+01	2.94E+03

Larger of Values from Above Two Data Sets						
129I	14C	79Se	99Tc	Cr	NO2	NO3
9.25E-04	9.99E-02	1.34E-03	4.81E-01	5.97E+01	6.87E+02	2.94E+03

Leak Inventory

Tank S-109 Tc-99 retrieval leak inventories are developed below based on the data and recommendations in DOE/ORP-2003-02 by assuming the waste composition of leaks during retrieval would be the same as the waste concentrations in the final residuals. The waste concentrations in final residuals are taken from either the Selected Phase Retention or Hanford Tank Waste Operation Simulator (HTWOS) modeling data set from Table A.2 of DOE/ORP-2003-02, which ever is larger (see Residual Inventory sheet in this workbook). The tank S-109 Retrieval leak inventories for the contaminants included in the screening procedure are then calculated as the product of the concentration and the assumed leak volume (8,000 gal for purposes of this evaluation).

Contaminant	Inventory in 360 ft³ (2,700 gal) Residual Waste Tank S-109 (Ci)[a]	Concentration in Retrieval Leak Fluid (Ci/gal)[b]	Assumed Retrieval Leak Volume (gal)	Inventory in Retrieval Leakage (Ci)
C-14	9.99E-02	3.70E-05	8000	2.96E-01
Se-79	1.34E-03	4.95E-07	8000	3.96E-03
Tc-99	4.81E-01	1.78E-04	8000	1.42E+00
I-129	9.25E-04	3.43E-07	8000	2.74E-03

[a]Source = DOE/ORP-2003-02, Table A.2 (lager of values from Selected Phase Retention or HTWOS data sets, see Residual Inventory sheet in this workbook)

[b]Calculated as residual waste inventory divided by residual waste volume

Contaminant	Inventory in 360 ft³ (2,700 gal) Residual Waste Tank S-109 (kg)[a]	Concentration in Retrieval Leak Fluid (kg/gal)[b]	Assumed Retrieval Leak Volume (gal)	Inventory in Retrieval Leakage (kg)
nitrate	2.94E+03	1.09E+00	8000	8.70E+03
nitrite	6.87E+02	2.54E-01	8000	2.03E+03
chromium VI[c]	5.97E+01	2.21E-02	8000	1.77E+02

[a]Source = DOE/ORP-2003-02, Table A.2 (lager of values from Selected Phase Retention or HTWOS data sets, see Residual Inventory sheet in this workbook)

[b]Calculated as residual waste inventory divided by residual waste volume

[c]Reported chromium inventory conservatively assumed to be entirely hexavalent chromium

Transfer Functions

Proportionality coefficients called transport transfer functions are used in lieu of performing new contaminant fate and transport modeling. The transfer functions are derived from the resullts of an S tank farm groundwater impacts analysis presented in RPP-7884. The RPP-7884 analysis focused solely on impacts from past releases and performed simulations for three contaminants of concern: technetium-99, nitrate, and hexavalent chromium. All three contaminants were simulated as being unretarded during subsurface transport (distribution coefficient = 0 mL/g). Mobile but moderately retarded contaminants were not simulated. The period of analysis was 1,000 years. Projected arrival times of peak groundwater concentrations at the S tank farm fenceline were approximately the year 2046 for all three contaminants.

Transfer functions for the tank S-109 evaluation are devloped for each of the RPP-7884 simulated contaminants by dividing the model-predicted peak groundwater concentrations at the tank farm fenceline by the contaminant inventories released at the source. The transfer functions are used to represent the unit contaminant concentrations in groundwater per unit inventory leaked at the source. The transfer functions calculated below are for ex-tank waste (past leaks, potential retrieval leaks). Transfer functions for in-tank waste (tank and ancillary equipment residuals) were not needed and were not developed. The technetium-99 transfer function is used to evalute radionuclide impacts, the nitrate transfer function is used for nitrate and nitrite impacts, and the chromium transfer function is used for chromium impacts. Nitrate is used rather than hexavalent chromium for nitrite impacts because it has the larger transfer function and therefore provides a more conservative estimate.

Technetium-99

Ex-Tank Waste (Past Leaks and Retrieval Leaks) =	2.80E+04	pCi/L per Ci
Peak Tc-99 groundwater concentration at fenceline across cross section projection from S-104 past leak (RPP-7884, Table G.3, cross-sect S-CC', Case 1) =	1.08E+05	pCi/L
Tc-99 inventory in S-104 past leak (RPP-7884, Table 3.4) =	3.87	Ci

Hexavalent Chromium

Ex-Tank Waste (Past Leaks and Retrieval Leaks) =	2.83E-03	mg/L per kg
Peak chromium groundwater concentration at fenceline across cross section projection from S-104 past leak (RPP-7884, Table G.3, cross-sect S-CC', Case 1) =	2.21E+00	mg/L
Cr (VI) inventory in S-104 past leak (RPP-7884, Table 3.4) =	7.81E+02	kg

Nitrate

Ex-Tank Waste (Past Leaks and Retrieval Leaks) =	3.91E-02	mg/L per kg
Peak nitrate groundwater concentration at fenceline across cross section projection from S-104 past leak (RPP-7884, Table G.3, cross-sect S-CC', Case 1) =	6.65E+02	mg/L
Nitrate inventory in S-104 past leak (RPP-7884, Table 3.4) =	1.70E+04	kg

Reference

RPP-7884, 2002, *Field Investigation Report for Waste Management Area S-SX*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington

Risk Factors

Radionuclide Groundwater Unit Risk Factors

Nuclide	Units	HSRAM Industrial[a]	HSRAM Residential[b]
C-14	cancer risk per pCi/L	7.77E-09	5.61E-08
	cancer risk per pCi/L		
	cancer risk per pCi/L		
	cancer risk per pCi/L		

[a]Source = HNF-SD-WM-TI-707, Rev. 3, Table 22
[b]Source = HNF-SD-WM-TI-707, Rev. 3, Table 26
HSRAM = Hanford Site Risk Assessment Methodology (DOE/RL-91-45)

Noncarcinogenic Chemical Groundwater Unit Hazard Factors

Chemical	Units	HSRAM Industrial[a]	HSRAM Residential[b]
nitrate	hazard index per mg/L	6.18E-03	3.98E-02
	hazard index per mg/L	9.89E-02	6.36E-01
	hazard index per mg/L		

[a]Source = HNF-SD-WM-TI-707, Rev. 3, Table 23
[b]Source = HNF-SD-WM-TI-707, Rev. 3, Table 27
HSRAM = Hanford Site Risk Assessment Methodology (DOE/RL-91-45)

Carcinogenic Chemical Groundwater Unit Risk Factors

Chemical	Units	HSRAM Industrial[a]	HSRAM Residential[b]
Arsenic	cancer risk per mg/L	4.31E-01	7.25E-01
Beryllium	cancer risk per mg/L	2.37E-01	3.91E-01
Cadmium	cancer risk per mg/L	1.78E-01	2.93E-01
Cobalt	cancer risk per mg/L	2.77E-01	4.56E-01
Chromium VI	cancer risk per mg/L	2.70E-05	6.00E-05

[a]Source = HNF-SD-WM-TI-707, Rev. 3, Table 23
[b]Source = HNF-SD-WM-TI-707, Rev. 3, Table 27
HSRAM = Hanford Site Risk Assessment Methodology (DOE/RL-91-45)

Reference

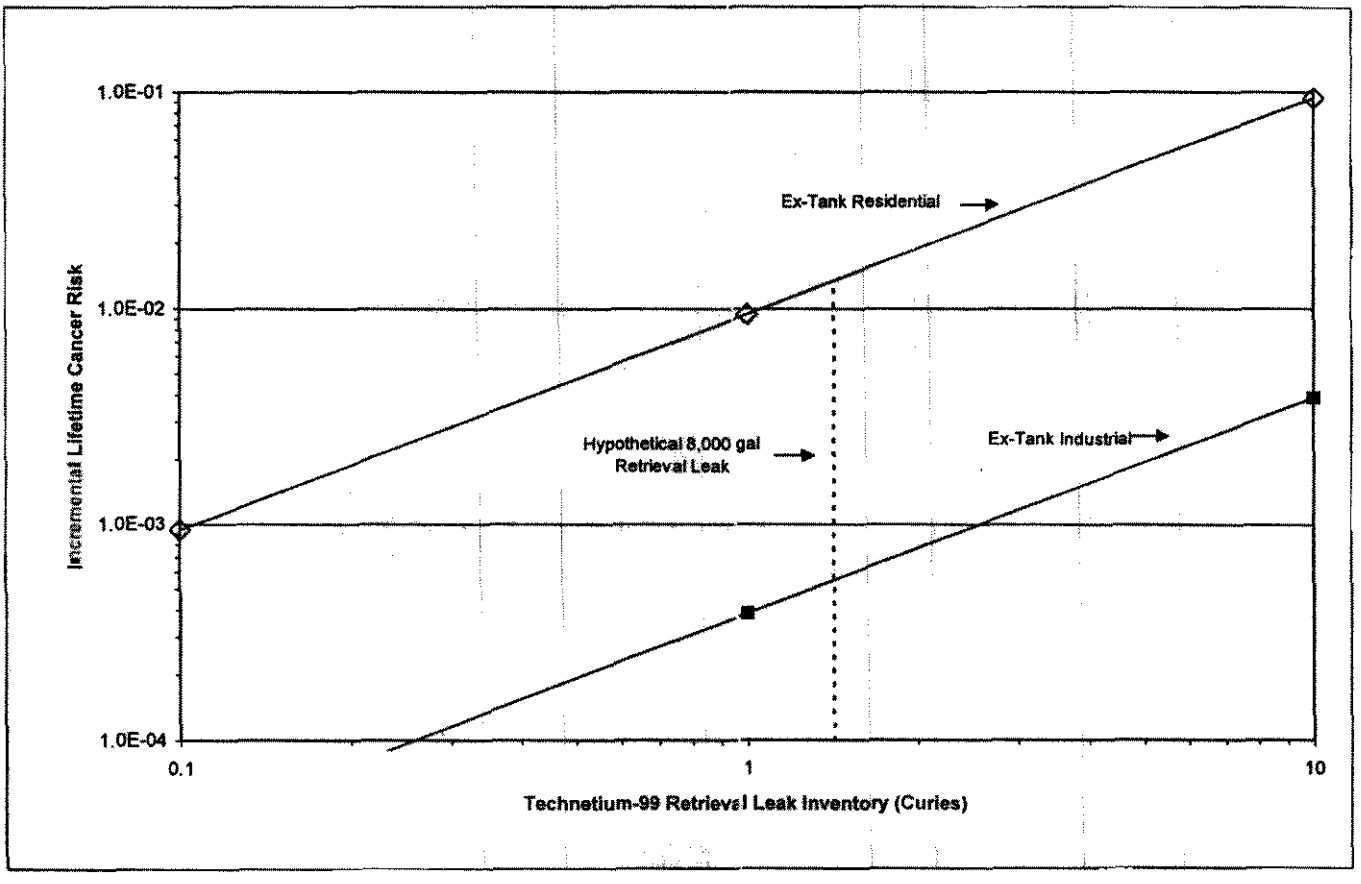
HNF-SD-WM-TI-707, 2003, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment*, Rev. 3, U. S. Department of Energy, Richland, Washington

Technetium-99 Plot
ILCR vs. Retrieval Leak Inventory

Technetium-99 Inventory (Ci)	Incremental Lifetime Cancer Risk (Linear extrapolation from Tc-99 transfer function)			
	In Tank Industrial	Ex Tank Industrial	In Tank Residential	Ex Tank Residential
0.1	N/A	3.86E-05	N/A	9.40E-04
1	N/A	3.86E-04	N/A	9.40E-03
10	N/A	3.86E-03	N/A	9.40E-02

N/A = not applicable

Tc-99 (Ci)	Residential ILCR	Worker ILCR
Hypothetical 8,000 gal Retrieval Leak from Tank S-109		
1.42E+00	1.00E-04	
1.42E+00	1.34E-02	5.50E-04

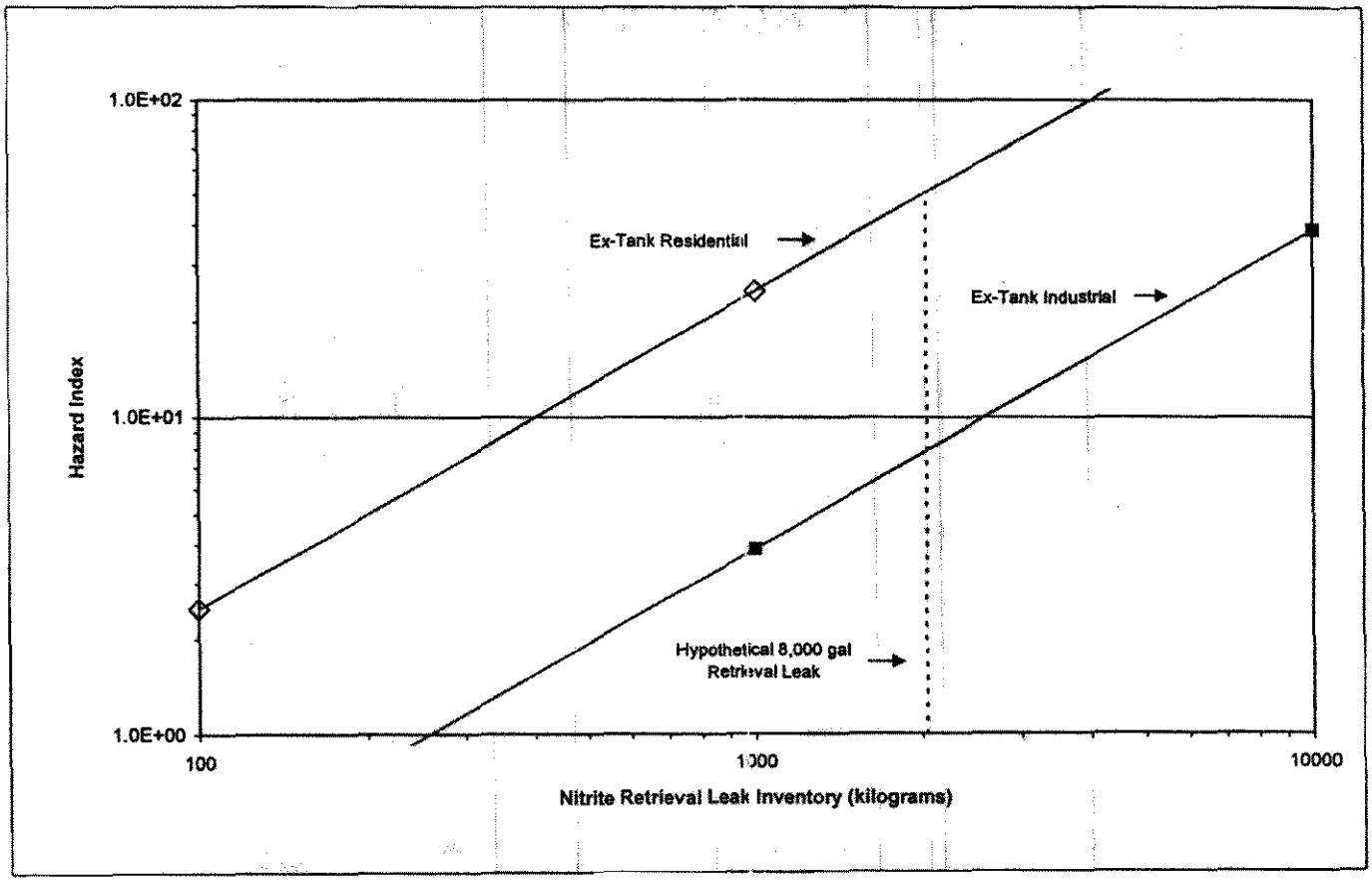


Nitrite Plot
Hazard Index vs. Retrieval Leak Inventory

Nitrite Inventory (kg)	Hazard Index (Linear extrapolation from nitrate transfer function)			
	In Tank Industrial	Ex Tank Industrial	In Tank Residential	Ex Tank Residential
100	N/A	3.87E-01	N/A	2.49E+00
1000	N/A	3.87E+00	N/A	2.49E+01
10000	N/A	3.87E+01	N/A	2.49E+02

N/A = not applicable

Nitrite (kg)	Residential Hazard Index	Worker Hazard Index
Hypothetical 8,000 gal Retrieval Leak from Tank S-109		
2.03E+03	1.00E+00	
2.03E+03	5.06E+01	7.86E+00



SPREADSHEET VERIFICATION FORM

2. **Spreadsheet Owner, Organization, MSIN, & Phone No.:**	D. Evans, CEES (Contractor), 946-7111			
3. **Spreadsheet File Name, Rev. No./Version No.**	F&R Risk Calcs,S109,Rev1C.xls			
4. **Location of Spreadsheet:** (Identify where the spreadsheet file is located by checking the boxes to the right. If "Other," provide description of where it is located)	**Personal Computer**	☐		
	CD	☐		
	Network Drive	☐	**Path**	
	Other	☒	**Description**	CEES (Contractor)
5. **Function and Purpose of Spreadsheet:** (Provide a brief description of the purpose of the spreadsheet)	Tank S-109 long-term human health risk calculations to support waste retrieval work plan (RPP-18812, Rev. 2).			
6. **Scope of Verification:** (Indicate scope of verification by checking box to right. If "Other" provide description of scope)	**All Formulas In Spreadsheet**	☐		
	Input Data only	☐		
	Formulas and Input Data	☒		
	Formula Changes	☐		
	Other	☐	**Description**	

7. **Method of Verification:** (Provide brief description of the method used to verify the spreadsheet. Note multiple methods may be used to verify different parts of a spreadsheet)

--Verified formulas used are correct for intended functions being calculated
--Performed hand calculations to verify values returned by formulas are correct (initial cells only for repeating formulas)
--Verified correct repetition used for repeating formulas
--Verified input data against data sources, checked for correct cell references in cells that call input data

8. **Verification Documentation:** (Provide description of where verification documentation may be located. The verification documentation should include a description of all unique intended formulae together with evidence that the interpretation of the formulae in the spreadsheet is correct and that the spreadsheet returns correct results)	**Attached:**	☐	**No. of Pages:**	
	Electronic Information File:	☐	**Ref:**	
	Engineering Document:	☒	**Ref:**	RPP-19136, Rev. 1

9. **Approvals**	Name:	Signature:	Date:
Spreadsheet Owner:	D. Evans	Doug Evans	6/29/2004
Spreadsheet Verifier:	D. Crumpler	Dwayne Crumpler	6/29/04
Owner's Manager:			

Figure 4. Subcontractor Calculation Review Checklist.

Page 1 of 1

Subject: ECN 722118 R.0 S-109 HUMAN HEALTH RISK CALCS

The subject document has been reviewed by the undersigned.
The checker reviewed and verified the following items as applicable.

Documents Reviewed: HUMAN HEALTH RISK CALCULATIONS

Analysis Performed By: CEES (CONTRACTOR)

- Design Input
- Basic Assumptions
- Approach/Design Methodology
- Consistency with item or document supported by the calculation
- Conclusion/Results Interpretation
- Impact on existing requirements
- N/A

Checker (printed name, signature, and date) STEVEN E. CARLSON Steve Carlson 9/22/2004

Organizational Manager (printed name, signature and date) D.H. Shuford D.H. Shuford 9/23/04