



U.S. Department of Energy
Office of River Protection

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AUG 25 2005

05-TPD-080

Mr. Scott C. Flanders, Director
Environmental and Performance
Assessment Directorate
Division of Waste Management
and Environmental Protection
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Mr. Flanders:

SUBMITTAL OF THE U.S. DEPARTMENT OF ENERGY, OFFICE OF RIVER PROTECTION (ORP) FINAL RESPONSES TO THE U.S. NUCLEAR REGULATORY COMMISSION REQUEST FOR ADDITIONAL INFORMATION (RAI) FOR SINGLE-SHELL TANK (SST) 241-C-106, RPP-RPT-26695


Reference: NRC letter from A. H. Bradford to R. J. Schepens, ORP, "Request for Additional Information on the Office of River Protection's Basis for Exception to the Hanford Federal Facility Agreement and Consent Order Waste Retrieval Criteria for Single-Shell Tank 241-C-106," dated January 19, 2005.

Enclosed please find ORP's final responses to your staff's RAIs provided in the Reference. These responses incorporate feedback on draft responses received from your staff at a meeting on June 1, 2005.

As noted in the Reference, ORP understands that you cannot complete your review of Tank C-106 exception request until after you have reviewed the Performance Assessment (PA) used to develop the estimate of risks for the material remaining in the tank. To satisfy this concern, ORP expects to provide the SST PA to you by December 2005. To help expedite your review of the SST PA, ORP recently provided to you under separate cover a partial draft of the SST PA.

If you have any questions, you may call me, or your staff may contact Roger Quintero, Tank Farms Programs and Projects Division, (509) 373-0421 or by e-mail at (Roger_A_Quintero@orp.doe.gov).

Sincerely,


Roy J. Schepens
Manager

TPD:RAQ

Enclosure

cc: See page 2

Mr. Scott C. Flanders
05-TPD-080

-2-

AUG 25 2005

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**Enclosure
05-TPD-080**

**RPP-RPT-26695, Rev. 0
NRC Staff Comments and DOE-ORP Responses Associated with DOE-ORP Documents
Establishing the Extent of Retrieval for Tank 241-C-106**

**(42 pages total
including coversheet)**

NRC Staff Comments and DOE-ORP Responses Associated with DOE-ORP Documents Establishing the Extent of Retrieval for Tank 241-C-106

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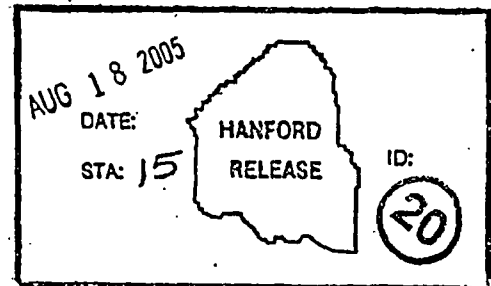
Key Words: Extent of Retrieval, 241-C-106, NRC Staff Comments, DOE-ORP Responses

Abstract: This report contains technical comments from the NRC staff and responses prepared for DOE-ORP by CH2MHILL to document establishing the extent of retrieval for tank 241-C-106.

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Janis Aardal 8/18/05
Release Approval Date



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Approved For Public Release

EXECUTIVE SUMMARY

In May 2004, the U.S. Department of Energy, Office of River Protection, released a series of documents addressing the retrieval of waste from single-shell tank 241-C-106. The reports documented retrieval activities completed through December 2003 and analysis of the extent of retrieval, residual wastes, and the costs and consequences of potential additional retrieval activities. The three documents included:

- RPP-20658, Rev. 0, *Basis for Exception to the Hanford Federal Facility Agreement and Consent Order Waste Retrieval Criteria for SST 241-C-106*
- RPP-20110, Rev. 1, *Stage I Retrieval Data Report for Single-Shell Tank C-106*
- RPP-20577, Rev. 0, *Stage II Retrieval Data Report for Single-Shell Tank C-106*.

The Office of River Protection provided each of the released documents to the U.S. Nuclear Regulatory Commission for staff review and comment. In January 2005, the U.S. Nuclear Regulatory Commission staff provided the Office of River Protection comments on the subject documents that included 12 specific technical comments and four clarifying comments. The specific technical comments provided by the U.S. Nuclear Regulatory Commission staff included a comment, basis for the comment and a suggested path forward for resolution of the comment.

In June 2005, the Office of River Protection met with the U.S. Nuclear Regulatory Commission staff to review draft responses to the U.S. Nuclear Regulatory Commission staff comments on the subject documents. Based on the discussion between the Office of River Protection and the U.S. Nuclear Regulatory Commission staff the Office of River Protection responses to the comments have been revised and made final.

This document provides the full text of the U.S. Nuclear Regulatory Commission staff comments, basis of comment, and path forward as well as the final Office of River Protection responses to the comments. The document also includes a list of all references cited in the responses to the comments. The responses include commitments to make revisions to the documents reviewed by the U.S. Nuclear Regulatory Commission staff. The revisions to the documents will be made and the documents will be issued in a timely manner.

TABLE OF CONTENTS

1.0	SPECIFIC TECHNICAL COMMENTS	1
1.1	COMMENT 1	1
	1.1.1 Basis.....	1
	1.1.2 Path Forward.....	1
	1.1.3 Response	1
1.2	COMMENT 2	3
	1.2.1 Basis.....	3
	1.2.2 Path Forward.....	3
	1.2.3 Response	3
1.3	COMMENT 3.....	4
	1.3.1 Basis.....	4
	1.3.2 Path Forward.....	4
	1.3.3 Response	4
1.4	COMMENT 4.....	4
	1.4.1 Basis.....	5
	1.4.2 Path Forward.....	5
	1.4.3 Response	5
1.5	COMMENT 5.....	9
	1.5.1 Basis.....	9
	1.5.2 Path Forward.....	9
	1.5.3 Response	9
1.6	COMMENT 6.....	9
	1.6.1 Basis.....	10
	1.6.2 Path Forward.....	10
	1.6.3 Response	10
1.7	COMMENT 7.....	11
	1.7.1 Basis.....	11
	1.7.2 Path Forward.....	12
	1.7.3 Response	12
1.8	COMMENT 8.....	12
	1.8.1 Basis.....	13
	1.8.2 Path Forward.....	13
	1.8.3 Response	13
1.9	COMMENT 9.....	14
	1.9.1 Basis.....	14
	1.9.2 Path Forward.....	14
	1.9.3 Response	14
1.10	COMMENT 10.....	15
	1.10.1 Basis.....	15
	1.10.2 Path Forward.....	16
	1.10.3 Response	16
1.11	COMMENT 11.....	16
	1.11.1 Basis.....	16
	1.11.2 Path Forward.....	16
	1.11.3 Response	16

1.12	COMMENT 12	17
1.12.1	Basis	17
1.12.2	Path Forward	17
1.12.3	Response	17
2.0	CLARIFYING COMMENTS	18
2.1	COMMENT 1	18
2.1.1	Path Forward	18
2.1.2	Response	19
2.2	COMMENT 2	19
2.2.1	Path Forward	19
2.2.2	Response	19
2.3	COMMENT 3	19
2.3.1	Path Forward	19
2.3.2	Response	20
2.4	COMMENT 4	20
2.4.1	Path Forward	20
2.4.2	Response	20
3.0	REFERENCES	20

ATTACHMENTS

ATTACHMENT 1 – SST POST-RETRIEVAL RESIDUAL CONTAMINANT SURVEY PROCESS	A1-i
ATTACHMENT 2 – POST-RETRIEVAL RISK RESULTS	A2-i

LIST OF TABLE

Table 1. Technetium-99 Unit Dose Factors	18
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LIST OF TERMS

Abbreviations, Acronyms, and Initialisms

CCMS	Camera/CAD Modeling System
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DQO	data quality objectives
DST	double-shell tank
Ecology	Washington State Department of Ecology
HFFACO	<i>Hanford Federal Facility Agreement and Consent Order</i>
HI	Hazard Index
ILCR	incremental lifetime cancer risk
OLS	ordinary least squares
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
REML	restricted maximum likelihood estimation
SST	single-shell tank
UCL	upper confidence level

Units

%	percent
°C	degrees Celsius
°F	degrees Fahrenheit
Ci	Curie
gal.	gallon
L	liter
mL	milliliter
pCi/L	picoCuries per liter

1.0 SPECIFIC TECHNICAL COMMENTS

1.1 COMMENT 1

Additional information is required to evaluate the conclusion that dissolution with oxalic acid is the best available chemical treatment of sludge.

1.1.1 Basis

Evidence that alternate chemical treatments could not dissolve the sludge to a greater extent, or would be impractical to implement, is necessary to support the conclusion that the sludge has been removed to the extent that is technologically practical.

1.1.2 Path Forward

Provide the expected efficiency of alternative chemical treatments available for sludge dissolution (other than oxalic acid), or provide information that demonstrates the application of an alternative chemical treatment is not technologically practical.

Provide the description of chemical treatment of sludge and sludge dissolution data provided in RPP-17158, *Laboratory Testing of Oxalic Acid Dissolution of Tank 241-C-106*.

1.1.3 Response

Several chemical reagents were considered before oxalic acid was selected. Scoping tests were performed on simulated sludge samples at Pacific Northwest National Laboratory (PNNL-14378, *Candidate Reagents for Dissolution of Hanford Site Tank Sludges—Scoping Studies with Simulants using Single Reagents and Their Mixtures*) with a wide range of dissolving agents. See Table 1 in the report for a complete list of reagents, which included oxalic acid, nitric acid, hydrofluoric acid, acetic acid, EDTA, HEDTA, citric acid, and 15 other less-well-known reagents. The report concluded that, while no single reagent was capable of dissolving all five of the major solid phases present in single-shell tank (SST) 241-C-106 sludge, the best overall performers were oxalic acid and hydrofluoric acid. The latter was not seriously considered for application in SST 241-C-106 because of health and safety concerns and corrosion concerns. Similar scoping studies performed at the Savannah River Site with actual tank waste sludge concluded (WSRC-TR-2003-00401, *Waste Tank Heel Chemical Cleaning Summary*):

The results of the evaluation conclusively support oxalic acid as the cleaning agent of choice.... Oxalic acid scored nearly double the next closest cleaning agent.... Oxalic acid has been widely studied and used several times to clean HLW tanks at SRS and at other sites within the DOE complex.... Oxalic acid has been shown to be effective for a wide variety of sludge types and out-performed nitric acid and other chemical cleaning agents in head-to-head tests.... Oxalic acid offers the generic ability to work on most sludge types.

Other reagents tested at the Savannah River Site included nitric acid, formic acid, mixed oxalic/citric acids, mixed oxalic/nitric acids, oxalic acid with hydrogen peroxide, and several organics. Unpublished results (viewgraph presentation) from Argonne National Laboratory showed that oxalic acid was much better than nitric acid at dissolving iron oxide/hydroxide, and nearly as effective as hydrochloric acid. Hydrochloric acid was never seriously considered for application to SST 241-C-106 sludge because of its very high corrosion potential, its potential to generate poisonous gases, and its adverse impact on downstream processing. Finally, caustic leaching (sodium hydroxide) was eliminated from consideration based on results of studies with actual SST 241-C-106 sludge performed by Pacific Northwest National Laboratory (PNWD-3013, *C-106 High-Level Waste Solids: Washing/Leaching and Solubility Versus Temperature Studies*).

Laboratory testing at the 222-S Laboratory with actual SST 241-C-106 sludge (RPP-17158) was performed with the goal of answering a number of processing uncertainties:

1. Would oxalic acid dissolve the sludge? (Up to 70% of the sludge was dissolved.)
2. How much acid would be required? (The optimum volume ratio was 35 parts acid to 2 parts sludge.)
3. How long would the dissolution reaction take? (Reaction was nearly complete after one day of contact.)
4. Was the acid addition more effective as one large batch or several smaller batches? (Results were the same for both methods.)
5. What gases, and how much, were produced? (Mainly CO₂, traces of H₂ and CH₄, 190 mL gas per 1 mL sludge).
6. What would be the impact on solids volume in the receiver tank, double-shell tank (DST) 241-AN-106? (Volumes of easily-compacted phosphate and oxalate salts were projected.)
7. Would mixed nitric/oxalic acid dissolve more sludge than oxalic acid alone? (There was no significant difference.)
8. What solid phases were present in the sludge? (Dawsonite, hematite, gibbsite and cancrinite were the major phases.)

9. What is the chemical/radionuclide composition of the undissolved sludge residue?
[See Tables 7-3 through 7-11 in RPP-17158, *Laboratory Testing of Oxalic Acid Dissolution of Tank 241-C-106*.]
10. How much NaOH needed to be added to the receiver tank, DST 241-AN-106, to neutralize the acidified sludge? (1.8 moles NaOH per liter of leachate.)

1.2 COMMENT 2

Additional information is required to ensure that the conditions under which oxalic acid was used to dissolve tank sludge were the most favorable conditions that were technologically practical.

1.2.1 Basis

The documents reviewed do not provide information on the temperature of the acid used during the chemical dissolution process or the expected effect of temperature on the efficacy of acid removal. Temperature can be an important parameter in the stability and dissolution of solid materials. Evidence that a temperature in the optimal range was used is necessary to support the conclusion that the technical removal method used resulted in sludge dissolution to the maximum extent that is technologically practical.

1.2.2 Path Forward

Provide a discussion of the effects of temperature on tank sludge dissolution showing either that alternate operating temperatures would not cause the sludge to dissolve to a greater extent or that it would not be technologically practical to implement the chemical treatment procedure at a different temperature.

1.2.3 Response

The tests of oxalic acid dissolution of sludge conducted in the laboratory were at ambient temperature, about 23 °C (74 °F). The reactions were fairly rapid at that temperature – most of the dissolution occurred in the first day. The amount of sludge that dissolved was controlled by the chemical composition of the acid and the sludge, not by the temperature. Approximately 30% of the sludge did not dissolve in oxalic acid. Even though the sludge was allowed to react for several days, the amount of sludge that dissolved did not appreciably increase after the first day. An analysis of the sludge residue was conducted. The analysis confirmed that the residue contained chemical compounds that would not dissolve in oxalic acid (RPP-17158).

The acid used in SST 241-C-106 was typically started at a warmer temperature than the laboratory tests, but less than 100 °F. Implementation of the chemical treatment procedure above

his temperature was limited by the temperature controls for the tank. Given the tank temperature constraints, further investigation into the effects of temperature was impractical. However, each acid batch was left in the tank for several days to react with the sludge to ensure the reaction reached its fullest extent under the reaction conditions. Based on the residence time of each acid batch and the results from the laboratory, the oxalic acid reaction with the sludge should have gone to completion for each batch.

1.3 COMMENT 3

Additional information is needed to evaluate Alternative Removal Method C, Modified Sluicing Followed by New Vacuum Retrieval System (RPP-20577).

1.3.1 Basis

It is unclear why modified sluicing must be used for the first 795 L (210 gal.) of waste removal instead of using the Vacuum Retrieval System to remove all of the residual waste in SST 241-C-106. Using sluicing to remove the first 795 L (210 gal.) of residual waste increases the water usage and the use of DST storage and therefore impacts the technological practicality of the removal option.

1.3.2 Path Forward

Provide an explanation of why additional sluicing must be performed prior to the activation of the Vacuum Retrieval System or provide an analysis of the expected cost and benefits of using the Vacuum Retrieval System to remove all of the residual waste in SST 241-C-106.

1.3.3 Response

The vacuum system has limited 'reach' within the tank. By using sluicing, the solids are moved toward the location of the vacuum system to improve vacuum system efficiency. Without sluicing, the solids are too dispersed in the tank and the vacuum system cannot reach enough solids to achieve the desired end volume.

1.4 COMMENT 4

The basis for using the 95th percentile upper confidence level (UCL) of residual waste remaining in the tank to compute the volume of residual waste that would need to be removed to meet the residual waste requirement 10.2 m³ (360 ft³) established in the Ecology et al. (1989), *Hanford Federal Facility Agreement and Consent Order*, is unclear. Similarly, if the 95th percentile UCL

is justified as the basis for the removal goal, it is unclear why a removal goal of 4.53 m^3 (160 ft^3) was used in the comparison of the alternative removal technologies instead of the difference between the 95th percentile UCL and the removal requirement of 10.2 m^3 (360 ft^3), or 3.03 m^3 (107 ft^3).

1.4.1 Basis

Although the removal goal reportedly was chosen to be conservative (RPP-20577, p. 4-4), the effect of using a 'conservatively' large removal goal rather than a removal goal based on the best estimate of waste in the tank is to increase projected water usage and removal costs. In addition, results of a 'worst case' analysis of the estimated success of continued use of current technology (modified sluicing and oxalic acid dissolution) (RPP-20577, p. 1-5 and 1-6) indicate that up to 1.27 m^3 (44.8 ft^3) could be removed with the existing technology. This additional removal would be sufficient to decrease the best estimate of the residual waste volume to below 10.2 m^3 (360 ft^3) and to meet the removal goal specified in the *Hanford Federal Facility Agreement and Consent Order*.

1.4.2 Path Forward

Provide additional justification for the removal goal of 4.53 m^3 (160 ft^3) used in the analysis of potential alternative removal technologies. Alternately, explain why basing the removal goal on the best estimate of the difference between the waste volume left in the tank and the residual waste required of 10.2 m^3 (360 ft^3) would not change the conclusion of retrieval sufficiency. Address why the 95th percentile UCL of waste remaining in the tank was used rather than an UCL based on a lower percentile and why an additional 1.50 m^3 (53 ft^3) were included in the removal goal to result in a goal of 4.53 m^3 (160 ft^3).

1.4.3 Response

The endpoint was established based on the measurement capability of the endpoint, not the incremental amount removed. At the endpoint of 200 ft^3 , the measurement accuracy would ensure that the actual volume is less than 360 ft^3 at the 95% confidence interval. Section 2.2.1.2 in RPP-20658, *Basis for Exception to the Hanford Federal Facility Agreement and Consent Order Waste Retrieval Criteria for SST 241-C-106*, reads as follows:

While it is the overall goal to define systems that will remove as much of the residuals as possible, the alternatives described below are discussed in the context of a common "minimum volume goal" of 200 ft^3 (i.e., removal of 160 ft^3). At the 95% confidence interval of residual waste remaining in a tank, 467 ft^3 are present in the tank and the alternative retrieval technology selected must retrieve at least an additional 107 ft^3 of waste from the tank to reach the 360 ft^3 residual waste volume requirement. To ensure the residual waste volume in the tank is less than or equal to the 360 ft^3 requirement, the removal volume goal was conservatively set at 160 ft^3 based on the estimation error.

associated with the residual waste volume determination and the additional uncertainties associated with the waste retrieval technology performance.

To provide a more complete analysis of the costs and benefits of additional retrieval of waste from SST 241-C-106, the analysis will be revised using the both the 95% residual waste volume and the nominal residual waste volume (approximately 370 ft³). The revised analysis will be included in a revision to the documents that will be prepared in response to these comments as well as those submitted by the Washington State Department of Ecology (Ecology).

Use of the 95% confidence interval for estimation of residual waste volume was established as the preferred method of reporting residual waste volume by Ecology. The basis for the preferred method and the application of the method is provided in RPP-19866, *Calculation for the Post-Retrieval Waste Volume Determination for Tank 241-C-106*.

The U.S. Department of Energy (DOE) completed the retrieval of waste in SST 241-C-106 and subsequent calculation of the residual waste volume. This work was conducted following the established data quality objectives (DQO), and sampling and analysis plan for SST 241-C-106. Determination of the post-retrieval residual waste volume is documented in RPP-19866. Tank bottom residual waste volumes were estimated using the Video Camera/CAD Modeling System (CCMS) and were estimated to be 348.19 ft³ (RPP-19866). The total volume of post-retrieval residual waste in SST C-106 and waste volumes associated with the various components are presented in RPP-18744, *Results of the Video Camera/CAD Modeling System Test*. The error values for the tank bottom estimates were calculated at the 80% and 95% confidence intervals. The 95% confidence interval was calculated as 27% yielding an upper bound residual waste volume of 442.2 ft³. The error determination was based on the nine data points obtained from the initial testing conducted at the Cold Test Facility and documented in RPP-18744.

As part of the lessons learned following retrieval of SST 241-C-106 and the residual waste volume determination including the error determination, reviews were conducted to assess the methodologies employed in the error calculation. The review in the logic of the methodology used in calculating the original confidence intervals for SST 241-C-106 indicate that the approach over-stated the confidence interval. There are four reasons that lead to this determination:

1. The approach calculated error based on the average of the three means from the three video data sets obtained in the original Cold Test Facility study.
2. Analysis produced a regression line in which the intercept of the line was forced through the origin
3. The analysis assumed a normal distribution of the data and applied statistics based on a two-tailed analysis (traditional bell-shaped curve)
4. The analysis established the Estimated Volume determined from the CCMS analysis as the predictor and the Actual Volume was the response variable.

The original analysis did not rely on classical ordinary least squares (OLS), which is based on minimization of the sum of the squared residuals

$$\frac{\Sigma(\text{Actual Waste Vol.} - \text{predicted Actual Waste Vol.})^2}{\Sigma(\text{Actual Waste Vol.} - \text{slope} * \text{Est. Waste Vol.})^2} =$$

RPP-18744 determined slope by averaging three slopes, each of which was the average of the three slopes of lines passing through the origin and one of the data points corresponding to a particular video camera used in the Cold Test Facility experiments used to calibrate the CCMS algorithm. The final slope determined was the average of the three average slopes and confidence intervals for the final slope were based on standard small sample ($n = 3$) analysis of the mean of a random sample from a population.

It was concluded that the analyses did not represent the best choice of statistical tools to determine how best to define a functional relationship:

$$\text{Actual Volume} = f(\text{Estimated Volume})$$

between the experimental observations obtained with multiple video imaging of the waste surface in a tank and the actual 'true' value of the waste volume in the tank. The appropriate approximate functional relationship should be based on a larger family of regression curves. The simplest expanded choice is to determine the best-fit line.¹

$$\text{Actual Volume} = \text{slope} * \text{Estimated Volume} + \text{intercept.}$$

By applying this approach, the best-fit OLS line does not pass through the origin and provides a significantly better fit to the data than the best-fit OLS line constrained to pass through the origin.

Based upon the review of the original approach four improvements were identified. These improvements include:

1. Use a larger sample size. The data population will be based on 19 points.
2. Consistent with U.S. Environmental Protection Agency guidance, the calculated 95% would be for only the one-tailed upper bound confidence interval.
3. The intercept will not be constrained to pass through the origin.
4. The analysis will be based on the Actual Volume being a function of the Estimated Volume.

These four improvements were then tested using four separate and distinct methodologies. The purpose of this testing was to ascertain if any of the improvements impose a bias in the confidence interval calculation, which would result in either an overestimation or underestimation in residual waste volume. All four methodologies produce an equation that is inclusive of the 95% confidence interval. This is viewed as a significant improvement over the

¹ A best fit line that is not constrained to pass through the origin.

previous methodology in that the residual waste volume inclusive of the 95% confidence interval can be immediately determined. The four methodologies tested were:

- Classical OLS
- Monte Carlo Simulation
- Kendall-Theil
- Bootstrap.

All four of the regression methodologies represent significantly different approaches to determining the 95% confidence interval yet all four approaches produced consistent results. Based on this, it was concluded that the four improvements to the confidence interval determination do not introduce a bias but do improve the confidence interval determination.

While it could not be concluded that the data are not representative of normally distributed data, the data do have the appearance of not being normally distributed. The U.S. Environmental Protection Agency recognizes that the Bootstrap methodology may be more appropriately applied to non-normal data sets in calculating the 95% confidence interval (OWSER 9285.6-10, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Site*). For this reason, the Bootstrap regression equation

$$\text{Actual Vol. @95\%UCI} = 1.043 \times \text{CCMS In-Tank Vol. Est.} + 0.852$$

was selected to be used to calculate residual waste volume from the CCMS volume measurements at the 95% upper bound confidence interval. RPP-RPT-22891, *Revised Methodology to Calculating Residual Waste Volume at 95% Confidence Interval*, presents the complete review and revised methodology development.

The Bootstrap methodology and associated equation have been incorporated as part of the DQO and the sampling and analysis plan for the SSTs for calculating the residual tank waste on the bottom of the tank that has been accepted by Ecology. Additional waste volume estimates will use the following methodology:

- If the in-tank video identifies residual waste adhering to an internal tank stiffener ring, then the volume of that waste is calculated based on the conservative assumption that the waste is uniformly distributed on the ring.
- Residual waste associated with abandoned in-tank equipment is calculated based on the conservative assumption that the waste completely fills the void space of the equipment.
- The amount of waste on the tank walls after retrieval is considered to be minimal and will be estimated on a case-by-case basis.

The total residual waste volume in the tank is calculated as the sum of:

- The residual waste on the tank bottom (waste volume @95%UCI ft³)
- The residual waste on the stiffener rings
- The residual waste in the abandoned equipment void space.

1.5 COMMENT 5

It is unclear why the inventory of chromium increases from a pre-retrieval best-estimate value of 2.9 kg to a post-retrieval best-estimate value of 3.79 kg (RPP-20658, Table 8).

1.5.1 Basis

The apparent increase in the inventory of chromium during the 2003 retrieval campaign may be significant to the determination of whether the retrieval operations have been successful because chromium is the dominant contributor to the Hazard Index (HI) (RPP-20577).

1.5.2 Path Forward

Provide an explanation of why the inventory of chromium increased from 2.9 kg prior to removal to 3.79 kg after the 2003 removal campaign. Consideration should be given to potential acid dissolution of steel.

1.5.3 Response

The pre-retrieval inventory for chromium contains a typographical error. The value should be 2.9×10^2 instead of 2.9×10^0 . The correction will be made to Table 8 of RPP-20658.

The typographical error was not identified during the review process used during the preparation of the document. The review process consisted of a three-stage review that included:

- Review by the authors and technical editors
- Review by subject matter experts and line managers
- Review by senior contractor and DOE managers and designated subject matter experts.

The document was prepared in accordance with TFC-BSM-AD-STD-02, *Editorial Standards for Engineering Documents*, and the review and approval was completed in accordance with procedures defined in TFC-ESHQ-Q-INSP-C-05, *Independent Review and Approval of Documents*.

1.6 COMMENT 6

The logical basis for using a 'worst case' estimate of the efficacy of additional sluicing and acid dissolution operations to support the conclusion that current methods could not achieve the waste removal goal is unclear.

1.6.1 Basis

RPP-20577, *Stage II Retrieval Data Report for Single-Shell Tank 241-C-106*, indicates a 'worst case' analysis shows that only 1.27 m³ (44.8 ft³) of waste could be removed with the existing modified sluicing and acid dissolution technologies. Although it is noted that "The actual waste volume reduction and efficiency per sluicing operation realized by continued sluicing would likely be greater than predicted by this estimate" (RPP-20577, p. 1-6), the estimate is used to support the conclusion that additional waste removal operations should not be undertaken. This analysis appears to be non-conservative because the 'worst case' removal estimate deliberately underestimates the amount of removal likely to result from additional removal efforts and thus is biased toward a decision not to pursue additional removal.

1.6.2 Path Forward

Provide an explanation of why the results of a 'worst case' estimate of the efficacy of additional sluicing and acid dissolution operations can be used to support the conclusion that "regardless of the number of additional modified sluicing and acid dissolution operations undertaken, the waste retrieval goal of less than 10.2 m³ (360 ft³) would not be reached" (RPP-20577, p. 1-5 and 1-6).

1.6.3 Response

When evaluating what it would take to remove sufficient waste to meet the waste retrieval goal of 10.2 m³ (360 ft³) or less, two retrieval efficiencies were considered. The two retrieval efficiencies are based on the performance of waste retrieval system in tank C-106 while capturing the uncertainties associated with continued operation of the retrieval methods deployed in the tank in December 2003. A declining waste retrieval efficiency was considered based on historical data and provided an upper end or "worst case" type of estimate of retrieval operating time and estimate of liquid additions during retrieval. The other retrieval efficiency considered was a constant retrieval efficiency estimate used to develop a nominal or "best case" estimate of retrieval operating time and liquid additions during retrieval. These two retrieval efficiencies are expected to bound the waste volume projections for continued operation of existing retrieval methods.

The subject text in RPP-20577, *Stage II Retrieval Data Report for Single-Shell Tank 241-C-106* (p. 1-5 to 1-6) will be deleted and replaced with the following:

The continued viability of the modified sluicing with acid dissolution technologies to remove waste from SST C-106 was assessed by extrapolation of the performance data provided in RPP-20110, *Stage I Retrieval Data Report for Single-Shell Tank 241-C-106*. The historical data were used with an assumed 60,000-gal. sluicing batch and two extrapolation methods to estimate waste removal efficiencies to provide a range on the number of sluicing operations needed to remove at least 99% of the waste from the tank. The actual waste volume reduction and efficiency per sluicing operation realized by continued sluicing likely is expected to be bounded by these extrapolation methods.

The first extrapolation method uses a constant waste removal efficiency for each sluicing operation. This constant removal efficiency method provides a reasonably optimistic estimate for continued tank waste removal because waste removal efficiencies remain constant even though there is less and less waste remaining in the tank. Using the waste removal efficiency value of 0.3% from results shown for Sluice Operation #4 in RPP-20110, it is estimated that six to seven more sluicing campaigns will be required to meet the waste retrieval target. These additional sluicing campaigns will require approximately 360,000 to 420,000 gal. of additional sluicing water.

The second extrapolation method uses the method described in Appendix G to calculate a declining waste removal efficiency function based on the historical waste removal efficiency results from RPP-20110. Using this declining removal efficiency method reflects the diminishing return concept and will result in longer retrieval operations and increased liquid volume estimates for continued tank waste removal. The estimate shown in Appendix D for Alternative A (p. D-3) uses a waste removal efficiency that declines from 1.0 to 0.07% and indicates that more than 1,800,000 gal. of sluicing water will be needed to meet the retrieval goal. In this scenario, the initial retrieval efficiency is assumed to be greater than the efficiency observed at the conclusion of the 2003 retrieval campaign (0.3%) due to improvements realized by operational experience, and then declining to 0.07%.

This analysis shows that under optimistic (constant) retrieval efficiencies, significant quantities of additional sluicing water will be required to remove residual tank waste and retrieval liquids would constrain the available DST storage capacity. If the declining retrieval efficiency approach is experienced, the waste retrieval goal may never be reached and/or the volume of retrieval liquids would rapidly exceed the available DST storage capacity, limiting capacity required to support addition tank waste retrievals.

1.7 COMMENT 7

The incremental lifetime cancer risk (ILCR) and HI threshold values used in the COPC screening process were based on a comparison of the performance goals to the predicted dose to an industrial receptor. The use of the predicted dose to an industrial receptor rather than a residential receptor requires a basis.

1.7.1 Basis

ILCR and HI values used in the COPC screening process were based on a comparison of the performance goals to the predicted dose to an industrial receptor. The use of a more reasonably conservative scenario to establish the threshold values of the ILCR or HI may lead to more contaminants being identified as COPCs. A statement is made that the "most likely future land use for the tank farm area is considered industrial" (RPP-20577, p. 3-6), however there was no additional basis for scenario selection.

1.7.2 Path Forward

Justify the use of the industrial land use scenario as a basis for the calculation of ILCR and HI values of contaminants or recalculate the ILCR and HI values based on a more reasonably conservative land use scenario. If ILCR and HI values are recalculated, repeat the contaminant screening process and repeat the risk analysis for any additional contaminants that were identified as COPCs with the new ILCR and HI values. In justifying the industrial land-use scenario, consideration should be given to the simulated long timeframes over which the compliance calculation will apply.

1.7.3 Response

All contaminants that were detected by the laboratory in the post-retrieval sample were included in the risk assessment, provided that contaminant had either cancer slope factors or reference dose. The question became how to include those contaminants for which the laboratory analyzed in the post-retrieval sample, but fell below the laboratory's detection limits. Because it was an undetected constituent, half the detection limit was used to calculate an inventory left in the tank residue and an industrial ILCR and HI was calculated based on that inventory. However, it was pointed out during the review this dropped off I-129, a known COPC in tank waste.

The screening process is being modified per comments received by DOE from Ecology and the U.S. Nuclear Regulatory Commission (NRC). DOE has agreed to revise the screening process to include all detected and non-detected contaminants in the risk assessment unless there is a specific technical basis for excluding a non-detected contaminant from the analysis. For those limited non-detected contaminants, a basis of exclusion would be provided in the revised risk assessment. (See Attachment 1 for the revised screening process along with the attached Tables #1 and #2 that provide dose, risk, and hazard quotients for all analytes from the post-retrieval sample.)

Industrial Scenario was used to ensure consistency with remediation taking place in the surrounding Central Plateau as documented in DOE/EIS-0222F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*. This approach to cleanup was advanced by stakeholders and regulators when establishing the Central Plateau Risk Framework and provided to DOE in the form of advice from the Hanford Advisory Board (#132) (a copy of this was provided to the NRC staff in June 2005). However, because of long timeframes involved for release of tank residue, a residential scenario will be calculated for ILCR and HI and an All Pathways Farmer will be calculated for dose in a revision to the risk assessment that will be incorporated into a revision of RPP-20577 and summarized in RPP-20658.

1.8 COMMENT 8

Additional information is needed to support the conclusion that all relevant contaminants were included in the risk analysis.

1.8.1 Basis

More information is necessary to evaluate the process for developing the DQOs. Because inventories were generated only for constituents identified in the DQOs, the concern is that there may be constituents that could impact the health of a potential receptor that were not identified in the DQOs. In addition, the meaning of the terms 'underlying hazardous constituents' and 'secondary constituents' used in the description of the DQO process is unclear. These terms must be explained to clarify the basis for excluding non-detected underlying hazardous constituents and secondary constituents from the risk analysis.

1.8.2 Path Forward

Provide an explanation of the procedure used to identify constituents that were included in the DQOs. Provide a basis for excluding non-detected constituents identified as underlying hazardous constituents or secondary constituents in the DQO from the risk analysis.

Provide the document RPP-13899, *Tank 241-C-106 Component Closure Action Data Quality Objectives*, Rev. 1.

1.8.3 Response

A copy of RPP-13889, Rev. 1, was provided to the NRC staff in June 2005. RPP-13889 contains the following statements:

1. "The DQO process was implemented in accordance with "Data Quality Objectives for Sampling and Analyses" (TFC-ENG-CHEM-C-16, Rev. A) and the U.S. Environmental Protection Agency (EPA QA/G4, *Guidance for the Data Quality Objectives Process* (EPA 2000), with some modifications to accommodate project or tank specific requirements and constraints" (p. 7).
2. "The strategy identifies specific or 'primary' constituents (Single-Shell Tank Part A Permit [Part A] CH2M HILL 2003], underlying hazardous constituents (UHC), and radionuclides from 10 CFR 61.55) that will be analyzed with the quality control (QC) specified in this DQO. The secondary constituents (those constituents that can be detected with the analytical methods being used but not a Part A, UHC, or 10 CFR 61.55 constituent) will be reported using the QC indicated in the strategy described for each analytical group" (p. 11).

Under *Resource Conservation and Recovery Act of 1976* land disposal restriction regulations (Title 40, *Code of Federal Regulations*, Part 268, "Land Disposal Restrictions"), when determining the treatment standard for a characteristic waste, in many cases, the treatment table refers to Title 40, *Code of Federal Regulations*, Part 268.48, "Universal Treatment Standards" (also known as the list of underlying hazardous constituents). The generator is responsible for identifying all listed constituents that are reasonably expected to be present in the waste stream.

In response to Ecology unless there are comments on the process used to screen contaminants for inclusion in the assessment of risk provided in RPP-20577 and summarized in RPP-20658, DOE has agreed to revise the screening process to include all detected and non-detected contaminants in the risk assessment unless there is a specific technical basis for excluding a non-detected contaminant from the analysis. For those limited non-detected contaminants, a basis of exclusion would be provided in the revised risk assessment. (See Attachment 2 for the revised screening process and notes.)

1.9 COMMENT 9

Additional information is necessary to support the conclusion that the estimated residual inventory in SST 241-C-106 reflects uncertainty in the composition of the residual waste.

1.9.1 Basis

Variability in the composition of the solid waste in SST 241-C-106 has not been described. Thus, it is unclear whether variability in the composition of the solid waste in SST 241-C-106 has been reflected in the inventory estimates. The concern is that variance in the waste characteristics could lead to greater than expected residual radioactivity in the tank.

1.9.2 Path Forward

Provide a description of the locations in SST 241-C-106 from which sludge samples were taken. Provide the number of samples used to estimate the uncertainty in the radiological composition of the post-retrieval inventory. Provide the sampling and analysis approach described in RPP-7625, *Best-Basis Inventory Process Requirements*.

Provide the sludge concentration data reported in RPP-20264, *Analytical Results for the Tank 241-C-106 Solid Clams Shell Samples Supporting Closure Action*. Provide the liquid grab sample concentration data provided in RPP-20226, *Analytical Results for Liquid Grab Sampling and Analysis Plan for Tank 241-C106 Component Closure*.

Provide the description of the statistical method used to determine the standard deviations in the normal inventory presented in RPP-6924, *Statistical Methods for Estimating the Uncertainty in the Best-Basis Inventories*.

1.9.3 Response

Because of the extensive mixing of the waste during multiple acid and sluicing campaigns and the mechanical agitation of the residual waste during sluicing operations the non-homogeneity of the waste on stiffener rings and at the base of the tank was assumed to be small.

The residual waste consisted of a combination of a refined silt-like material and larger coarse pieces of material. The silty material was produced from the larger pieces by erosion in the course of conducting retrieval. Thus, the silty material and the coarse material were assumed to be of the same composition.

A video of sluicing operations inside tank C-106 (provided to the NRC) shows waste being mixed as it is pushed across the bottom of the tank by the sluicing water. This video provides evidence that the residual waste was well-mixed before being sampled, and that the sample was thus representative of the overall composition of the residual waste.

Two field samples (a primary sample and a duplicate sample) were collected below a riser near the center of the tank. Each sample consisted of multiple clamshells to provide sufficient solid material for analysis. The laboratory performed duplicate analyses on the field primary sample. A mean and an overall variance were calculated for each reported analyte. The calculated overall variance includes variance components associated with sampling and analytical errors but does not include the variance component associated with waste non-homogeneity (assumed to be small).

RPP-20264 and RPP-20226 will be provided as requested.

Formulae given in Searle et al. (1992), *Variance Components*, were used to estimate the mean concentration and for all analytes that had 50% or more of their reported values greater than the detection limit, the standard deviation. These formulae are based on the restricted maximum likelihood estimation (REML) method. Basically, REML estimates the variance components based on residuals calculated after fitting by ordinary least square just the fixed effects of the model. REML takes into account the degrees of freedom used for estimating fixed effects when estimating the variance components. When the data set is balanced (i.e., the number of replicate analyses is the same for each sample), the REML mean is no different than a straight arithmetic mean. However, when the data set is unbalanced, the REML estimates are generated using calculated weights based on the variance components and sample size giving an estimate with more favorable statistical properties.

1.10 COMMENT 10

It is stated that "DOE continues to consult with the NRC regarding issues associated with near-surface disposal of radioactive waste" (RPP-20658, p. 2-39). It is unclear what this statement is referring to in terms of any arrangements between DOE and NRC for consultation regarding waste disposal.

1.10.1 Basis

Not applicable.

1.10.2 Path Forward

Clarify or delete this sentence.

1.10.3 Response

The following text will be deleted from Section 2.5 of RPP-20658: "DOE continues to consult with the NRC regarding issues associated with near-surface disposal of radioactive waste."

1.11 COMMENT 11

The volume of waste on the stiffener rings is estimated to be $0.490 \text{ m}^3 + 0.0850 \text{ m}^3$ ($17.3 \text{ ft}^3 + 3 \text{ ft}^3 - 0 \text{ ft}^3$) (RPP-20110, p. 15 and 16), but an estimate of 0.490 m^3 (17.3 ft^3) of waste on the stiffener rings was used in the estimate of the total amount of waste in the tank (RPP-20110, Table 4).

1.11.1 Basis

Because the estimated range of the volume of waste on the stiffener rings is 0.490 to 0.575 m^3 (17.3 ft^3 to 20.3 ft^3), it appears that the most optimistic estimate of the volume of waste on the stiffener rings was used in the estimate of the amount of residual waste in SST 241-C-106. Use of the most optimistic value of a parameter requires justification.

1.11.2 Path Forward

Clarify whether the reported uncertainty range was a typographical error or whether the most optimistic volume of waste on the stiffener rings was used. If the most optimistic value of waste on the stiffener rings was used, justify this choice.

1.11.3 Response

An average inventory was calculated for each analyte based on the mean concentration, mean density, and the best estimates of waste volumes (including the volume of waste on the stiffener rings). An upper bound inventory was calculated to account for analytical uncertainty and uncertainties associated with the estimated waste volumes.

To clarify, two values of the waste associated with the stiffener rings were used: the nominal volume of waste on the stiffener rings 0.490 m^3 (17.3 ft^3) and the upper uncertainty value 0.0850 m^3 (3.0 ft^3). The nominal volume of the waste on the stiffener rings was summed with

the nominal waste volumes associated with the tank bottom and equipment to estimate a nominal total waste volume. This value was used in conjunction with the mean concentration and mean density to estimate the nominal inventory for each analyte identified in the residual tank waste. Nominal inventories are provided in RPP-20577, Appendix A, Table 2-2.

An overall uncertainty associated with the nominal inventory was determined by calculating a standard deviation. The standard deviation represents analytical uncertainty associated with the mean concentration, mean density, and uncertainty associated with the nominal total volume. The uncertainty associated with the nominal total volume includes uncertainties associated with the estimates for volumes of waste on the stiffener rings, on the tank bottom, and in the equipment. A 95% UCL inventory was calculated using the nominal inventory and the standard deviation. The 95% UCL inventories are provided in RPP-20577, Appendix A, Table 2-4.

Throughout RPP-20257 and RPP-20658, tables will be modified to reflect the upper and lower confidence levels as well as the nominal values.

1.12 COMMENT 12

In Table 3-4 on page 3-18 of RPP-20577, the Hanford Site Radiological Assessment Methodology (HSRAM) (copy of this was provided to NRC staff in June 2005) incremental cancer risk values for the all-pathways farmer and Native American scenarios are 1.0×1.0^{-6} and 6.9×10^{-6} , resulting in a ratio of 6.9. The ratio of the all-pathways radiological dose in groundwater for these two receptors is 2.4. It is unclear why these ratios differ significantly.

1.12.1 Basis

Not applicable.

1.12.2 Path Forward

Provide an explanation as to why the incremental cancer risk values for the scenarios noted have a different ratio than the ratio for the all-pathways radiological dose in groundwater.

1.12.3 Response

HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessments*, calculates dose and ILCR per unit concentration in groundwater for a range of exposure scenarios. The difference in this ratio is due to the following:

- The doses (mrem) are the total dose the first year after irrigation starts. The ILCR is the total risk for either 30 years (All Pathways) or 70 years (Native American).

Because the Native American has a longer lifetime, the risk is proportionately larger. The unit dose factors per unit concentration for Tc-99 are as listed in Table 1 below.

The product of the dose ratio and the lifetime ratio is $2.42 \times 2.33 = 5.64$, which is closer to the ILCR ratio of 6.70.

Table 1. Technetium-99 Unit Dose Factors.

Unit	All-Pathways Farmer	Native American Scenario	Ratio
GW dose/pCi/L	1.73E-03	4.23E-03	2.42
ILCR/pCi/L	6.97E-07	4.67E-06	6.70
Lifetime (yr)	30	70	2.33

GW = groundwater.

ILCR = incremental lifetime cancer risk.

However, one detail omitted in the above comparison is the accumulation in the soil during the lifetime of exposure. This makes the average dose larger than the first year dose. The 30-year average dose for the All Pathways Farmer is shown in Appendix G of HNF-SD-WM-TI-707, 8.73×10^{-3} mrem/yr per pCi/L. The calculated 70-year average dose for the Native American is 2.50×10^{-2} mrem/yr per pCi/L. The ratio of these two doses is 2.86. Scaling up by the ratio of averaging periods gives 6.67.

2.0 CLARIFYING COMMENTS

2.1 COMMENT 1

The peak ILCR due to residual waste in SST 241-C-106 is identified as 2.48×10^{-8} (RPP-20658, p. ES-3). This value is inconsistent with the ILCR due to residual waste in SST 241-C-106 shown in Figure ES-3 of RPP-20658. In addition, the ILCR reduction is identified in the text and in text included in Figure ES-3 to be 5×10^{-9} , which is inconsistent with the reduction shown in Figure ES-3.

2.1.1 Path Forward

Identify the correct peak ILCR due to residual waste in SST 241-C-106 and the correct reduction in the ILCR predicted to occur if 4.53 m^3 (160 ft^3) of waste are removed from the tank.

1.1.2 Response

In RPP-20658, the figure on p. ES-3 will be modified to correct the risk curve to correspond with the data presented in Table 11 and Figure 11.

1.2 COMMENT 2

The pre-retrieval Tc-99 inventory in SST 241-C-106 is reported to be 0.887 Ci in one location [RPP-20658, Figure 5] and 2.87 Ci in another [RPP-20658, Table 8].

1.2.1 Path Forward

Identify the correct pre-retrieval inventory of Tc-99 in SST 241-C-106.

1.2.2 Response

RPP-20658, Figure 5, is in error and will be revised to reflect the text on page 2-27 and values in Table 8.

1.3 COMMENT 3

The cost per cubic foot of waste removed was reported to be \$5,170 in the 2003 retrieval campaign and to range from \$35,000 to \$84,000 for the removal alternatives considered (RPP-20577, p. 4-13 and 4-23). Thus, cost per cubic foot of waste removed for each of the evaluated alternatives ranges from approximately 7 to 16 times greater than the cost per cubic foot of waste removed in 2003. However, it also is reported that the cost per cubic foot of waste removed with the removal alternatives considered is expected to be a factor of 100 to 280 times greater than the cost per cubic foot of waste removed in 2003 (RPP-20577, p. 4-14 and 4-23).

2.3.1 Path Forward

Identify the correct ratios of the cost per cubic foot of waste removed for the alternatives evaluated as compared to the cost per cubic foot of waste removed in 2003.

2.3.2 Response

RPP-20577, p. 4-14, will be modified to read: "The cost per cubic foot of waste retrieved for the four additional evaluated alternatives would range from \$35,000/ft³ to \$84,000/ft³ or a factor of seven to 16 times greater than experienced for the 2003 retrieval campaign."

2.4. COMMENT 4

The abbreviation "K_d" is defined as the "dispersion coefficient" in the List of Terms of RPP-20577. The expected definition is "distribution coefficient."

2.4.1 Path Forward

Identify whether the abbreviation "K_d" is used to represent the dispersion coefficient in the text or whether the definition in the List of Terms is a typographical error.

2.4.2 Response

RPP-20577, p. vii, "List of Terms," will be modified to read "distribution coefficient."

3.0 REFERENCES

40 CFR 268, "Land Disposal Restrictions," *Code of Federal Regulations*, as amended.

40 CFR 268.48, "Universal Treatment Standards," *Code of Federal Regulations*, as amended.

DOE/EIS-0222F, 1999, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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HNF-SD-WM-TI-707, 2003, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessments*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

- OSWER 9285.6-10, 2000, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Site*, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.
- PNNL-14378, 2003, *Candidate Reagents for Dissolution of Hanford Site Tank Sludges—Scoping Studies with Simulants using Single Reagents and Their Mixtures*, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington.
- PNWD-3013, 2000, *C-106 High-Level Waste Solids: Washing/Leaching and Solubility Versus Temperature Studies*, Rev. 0, Battelle, Pacific Northwest Division, Richland, Washington.
- Resource Conservation and Recovery Act of 1976*, Public Law 94-580, 90 Stat. 2795, 42 USC 901 et seq.
- RPP-6924, 2000, *Statistical Methods for Estimating the Uncertainty in the Best-Basis Inventories*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-7625, 2003, *Best-Basis Inventory Process Requirements*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-13899, 2004, *Tank 241-C-106 Component Closure Action Data Quality Objectives*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-17158, 2003, *Laboratory Testing of Oxalic Acid Dissolution of Tank 241-C-106*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-18744, 2003, *Results of the Video Camera/CAD Modeling System Test*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-19866, 2004, *Calculation for the Post-Retrieval Waste Volume Determination for Tank 241-C-106*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-20110, 2004, *Stage I Retrieval Data Report for Single-Shell Tank 241-C-106*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-20226, 2004, *Analytical Results for Liquid Grab Sampling and Analysis Plan for Tank 241-C-106 Component Closure*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-20264, 2004, *Analytical Results for the Tank 241-C-106 Solid Clams Shell Samples Supporting Closure Action*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-20577, 2004, *Stage II Retrieval Data Report for Single-Shell Tank 241-C-106*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-20658, 2004, *Basis for Exception to the Hanford Federal Facility Agreement and Consent Order Waste Retrieval Criteria for SST 241-C-106*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-22891, 2004, *Revised Methodology to Calculating Residual Waste Volume at 95% Confidence Interval*, Rev. 0, CH2M HILL Hanford Group, Inc., Cenibark International, Inc. and Washington State University, Richland, Washington.

Searle, S. R., Casella, G., and McCulloch, C. E., 1992, *Variance Components*, Wiley, New York.

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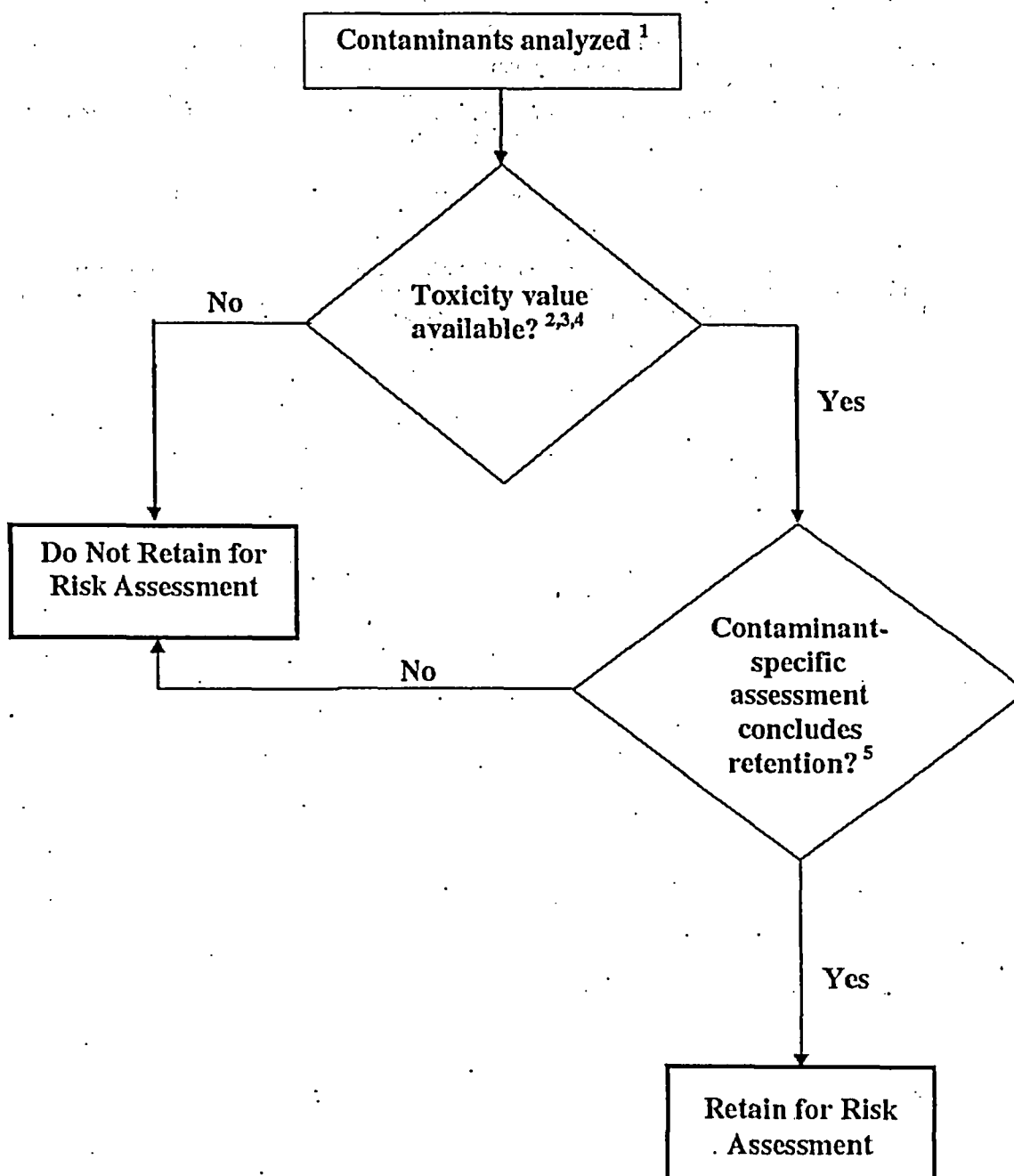
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Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina.

ATTACHMENT 1

**SST POST-RETRIEVAL RESIDUAL
CONTAMINANT SURVEY PROCESS**

SST Post-Retrieval Residual Contaminant Screening Process



February 22, 2005

Footnotes

¹ Contaminants analyzed and screened are identified in *Sampling and Analysis Plan for Single Shell Tanks Component Closure* (RPP-RPT-23623).

² Toxicity values should be obtained from IRIS, ORNL-RAIS, HEAST-rad, HEAST-nonrad, EPA Region 9 PRGs, and scientific literature. Priority is given to IRIS; however, when values are not available in IRIS the other databases should be used. Use of scientific literature is acceptable when approved by Ecology.

³ Detects obtained by using modified EPA SW-846 methods as summarized in the *Regulatory Data Objectives Optimization Report* (Arakali and others, February 2004), performed in accordance with requirements of Wiemers and others (*Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project*, PNNL-12040, Rev. 0-, Pacific Northwest National Laboratory, Richland Washington, USA, December 1998). The methods were developed for organic and inorganic chemical analysis in the tank matrices.

⁴ Contaminants that are not detected but retained for the risk assessment should be included at half of their detection levels.

⁵ Non-detected contaminants will be further screened to determine retention by the risk assessment group based on consideration of information including but not limited to historical process knowledge, manufacturing data, toxicity value source information, and potential for formation as a degradation product.

February 22, 2005

ATTACHMENT 2

POST-RETRIEVAL RISK RESULTS

Table 1. Radiological Contributors to C-106 Incremental Lifetime Cancer Risk and Radiological Dose

Analyte Name	Total Inventory ¹ (Ci)	Concentration (pCi/L) ²	Kd Bin	Half-Life (year)	HSRAM ILCR Industrial	HSRAM ILCR Residential	Dose All Pathways Farmer (mrem/yr)	MCL Limit Beta/Photon (mrem/yr)
Technetium-99	1.65E-01	1.43E+00	0	211097	1.96E-08	4.78E-07	2.50E-03	6.34E-03
Uranium-233	1.83E-03	2.30E-07	0.6	159198	8.33E-14	4.28E-13	4.66E-08	
Uranium-238 + D	9.04E-04	1.19E-07	0.6	4.47E+09	5.28E-14	2.80E-13	2.23E-08	
Uranium-234	9.48E-04	1.21E-07	0.6	245694	4.31E-14	2.22E-13	2.40E-08	
Uranium-235 + D	3.87E-05	5.08E-09	0.6	7.04E+08	2.02E-15	1.22E-14	9.56E-10	
Uranium-236	1.73E-05	2.27E-09	0.6	23420000	7.67E-16	3.94E-15	4.28E-10	
Iodine-129	3.16E-04	2.76E-03	0	15700000	2.05E-09	1.06E-08	1.45E-03	1.10E-02
Carbon-14	4.12E-03	2.35E-02	0	5730	1.82E-10	1.32E-09	1.14E-04	4.70E-05
Nickel-63	7.30E+01	0	>1	100.1	0	0	0	0
Strontium-90 + D	6.61E+04	0	>1	28.149	0	0	0	0
Cesium-137 + D	1.45E+03	0	>1	29.999	0	0	0	0
Thorium-228 + D	5.75E-04	0	>1	1.9129	0	0	0	
Thorium-230	8.82E-04	0	>1	75380	0	0	0	
Thorium-232	5.61E-04	0	>1	1.41E+10	0	0	0	
Neptunium-237 + D	5.42E-02	0	>1	2140000	0	0	0	
Plutonium-239	1.68E+01	0	>1	24110	0	0	0	
Plutonium-240	3.58E+00	0	>1	6563	0	0	0	
Plutonium-241 + D	3.97E+01	0	>1	14.35	0	0	0	0
Americium-241	6.53E+01	0	>1	432.7	0	0	0	
Tritium	5.10E-03	0	0	12.33	0	0	0	0
Cobalt-60	9.00E+00	0	0.1	5.2713	0	0	0	0
Selenium-79	4.80E-03	0	>1	805000	0	0	0	
Europium-152	3.14E+01	0	>1	13.33	0	0	0	0
Europium-154	4.07E+01	0	>1	8.5919	0	0	0	0
Europium-155	3.90E+01	0	>1	4.68	0	0	0	0
Plutonium-238	1.36E+00	0	>1	87.697	0	0	0	
Curium-242	7.90E-02	0	>1	0.44611	0	0	0	
Curium-243	1.51E-01	0	>1	28.499	0	0	0	
Curium-244	3.63E+00	0	>1	18.1	0	0	0	

Table 1. Radiological Contributors to C-106 Incremental Lifetime Cancer Risk and Radiological Dose

Analyte Name	Total Inventory ¹ (Ci)	Concentration (pCi/L) ²	Kd Bin	Half-Life (year)	HSRAM ILCR Industrial	HSRAM ILCR Residential	Dose All Pathways Farmer (mrem/yr)	MCL Limit Beta/Photon (mrem/yr)
Niobium-94	9.40E+00	0	>1	20300	0	0	0	
Ruthenium-106	1.69E+02	0	>1	1.01736	0	0	0	0
Antimony-125	3.17E+01	0	>1	2.7299	0	0	0	0
Cesium-134	8.70E+00	0	>1	2.0619	0	0	0	0
Radium-226 + D	2.09E+02	0	>1	1600	0	0	0	
Total					2.19E-08	4.90E-07	4.06E-03	1.74E-02

Footnotes: ¹ Total Inventory by constituent in the tank residual waste.

² Concentration of contaminants and/or risk associated with concentration of contaminants in groundwater at the Waste Management Area fence line. "0" denotes that contaminants were not present in groundwater at the Waste Management Area fence line.

No-shade in cells are detected analytes. Shaded cells are non-detected analytes with inventory calculated at ½ the detection limit. red analytes are analytes identified in the DQO as secondary, all others were identified as primary.

ILCR = Incremental Lifetime Cancer Risk

Table 2. Hazardous Chemicals Contributors to C-106 Incremental Lifetime Cancer Risk

CAS	Analyte Name	Total Inventory (Kg) ¹	Concentration (mg/L) ²	Kd Bin	HSRAM Industrial ILCR ²	HSRAM Residential ILCR ²	Residential MTCA B ²	Industrial MTCA C ²
7440-47-3	Chromium	3.79E+00	3.31E-05	0	4.96E-10	1.16E-09	NSF	NSF
7440-48-4	Cobalt	3.76E-01	2.09E-06	0.1	2.11E-11	6.77E-11	NSF	NSF
621-64-7	N-nitroso-di-n-propylamine*	6.79E-03	5.65E-08	0.01	1.15E-09	5.63E-08	4.52E-09	4.52E-09
79-46-9	2-Nitropropane	1.01E-04	8.81E-10	0	2.34E-10	3.85E-10	NSF	NSF
79-01-6	1, 1, 2-Trichloroethylene	8.12E-05	6.76E-10	0.01	8.66E-12	1.72E-11	6.18E-12	6.18E-12
88-06-2	2, 4, 6-Trichlorophenol	5.85E-03	4.38E-08	0.03	3.25E-12	1.49E-11	5.51E-12	5.51E-12
79-34-5	1, 1, 2, 2-Tetrachloroethane	4.22E-05	3.52E-10	0.01	2.19E-12	4.57E-12	1.61E-12	1.61E-12
56-23-5	Carbon tetrachloride	7.61E-05	6.66E-10	0	1.25E-12	2.91E-12	1.98E-12	1.98E-12
67-66-3	Chloroform	6.11E-05	5.34E-10	0	1.21E-12	2.00E-12	2.81E-15	2.81E-15
107-06-2	1, 2-Dichloroethane	4.17E-05	3.64E-10	0	1.03E-12	2.16E-12	7.58E-13	7.58E-13
75-01-4	Chloroethene	2.90E-05	2.53E-10	0	6.40E-13	6.08E-12	8.11E-12	4.17E-12
79-00-5	1, 1, 2-Trichloroethane	4.22E-05	3.51E-10	0.01	6.23E-13	1.30E-12	4.58E-13	4.58E-13
71-43-2	Benzene	4.04E-05	3.36E-10	0.01	3.15E-13	7.27E-13	4.23E-13	4.23E-13
127-18-4	Tetrachloroethylene	5.31E-05	4.42E-10	0.01	9.99E-14	3.89E-13	5.25E-13	5.25E-13
100-41-4	Ethylbenzene	1.01E-04	8.39E-10	0.01	9.12E-14	1.50E-13	NSF	NSF
75-09-2	Dichloromethane	4.94E-05	4.32E-10	0	2.93E-14	9.19E-14	7.40E-14	7.40E-14
106-46-7	1, 4-Dichlorobenzene	1.04E-02	7.76E-08	0.03	5.47E-11	1.10E-10	4.26E-11	4.26E-11
87-86-5	Pentachlorophenol	5.19E-03	3.89E-08	0.03	2.16E-11	9.49E-11	5.33E-11	5.33E-11
7440-43-9	Cadmium	1.44E+00	0	>1	0	0	NSF	NSF
7440-38-2	Arsenic	1.45E+00	0	>1	0	0	0	0
7440-41-7	Beryllium	2.83E-02	0	>1	0	0	NSF	NSF
87-68-3	Hexachlorobutadiene	2.65E-03	0	>1	0	0	0	0
67-72-1	Hexachloroethane	3.80E-05	0	>1	0	0	0	0
Total					1.93E-09	5.79E-08	4.62E-09	4.62E-09

Footnotes: ¹ Total Inventory by constituent in the tank residual waste.

²Concentration of contaminants and/or risk associated with concentration of contaminants in groundwater at the Waste Management Area fence line.
 "0" denotes that contaminants were not present in groundwater at the Waste Management Area fence line.

No-shade in cells are detected analytes; Shaded cells are non-detected analytes with inventory calculated at ½ the detection limit, red analytes are analytes identified in the DQO as secondary, all others were identified as primary.

NSF = No slope factor for ingestions for incremental lifetime cancer risk.

Detection limits for analytes provided in RPP-20577 Rev. 0, Stage II Retrieval Data Report.

*In this table, N-nitroso-di-n-propylamine was added to the total. Under the new screening methodology, this analyte would undergo further research to determine if it should be included in the total ILCR. This research would include what is the use of this chemical and is it likely that it is suspected to be in tank waste. Alternatively, the laboratory could be asked to reduce its detection limit.

Table 2. Hazardous Chemicals Contributors to C-106 Hazard Index

CASRN	Analyte Name	Total Inventory (Kg)	Concentration (mg/L)	Kd Bin (ml/g)	HSRAM HQ Industrial	HSRAM HQ Residential	MTCA B HQ Residential	MTCA C HQ Industrial
18540-29-9	Chromium	3.79E+00	3.31E-05	0	1.29E-04	7.74E-04	8.52E-04	3.41E-04
7440-48-4	Cobalt	3.76E-01	2.09E-06	0.1	2.36E-06	9.61E-06	1.21E-05	4.83E-06
78-93-3	2-Butanone(MEK)	4.48E-04	3.92E-09	0	3.35E-10	1.35E-09	8.16E-10	3.73E-10
67-64-1	2-Propanone (Acetone)	1.30E-03	1.14E-08	0	1.24E-10	2.89E-09	1.58E-09	7.23E-10
84-74-2	Di-n-butylphthalate	4.23E-03	5.56E-13	0.6	6.56E-14	4.36E-13	1.25E-12	4.99E-13
14797-65-0	Nitrite	2.08E+01	1.81E-04	0	1.80E-05	1.15E-04	1.13E-04	5.18E-05
98-95-3	Nitrobenzene	5.02E-03	4.18E-08	0.01	7.93E-06	1.93E-05	5.22E-06	2.39E-06
88-06-2	2, 4, 6-Trichlorophenol	5.85E-03	4.38E-08	0.03	5.74E-06	4.16E-05	2.74E-05	1.25E-05
91-20-3	Naphthalene	4.80E-03	2.66E-08	0.1	3.09E-06	3.48E-06	1.67E-07	7.61E-08
71-36-3	n-Butyl alcohol (1-butanol)	1.08E-02	9.48E-08	0	1.31E-06	1.56E-06	5.92E-08	2.71E-08
14797-55-8	Nitrate	2.31E+01	2.02E-04	0	1.25E-06	8.01E-06	7.87E-06	3.60E-06
106-44-5	4-Methylphenol (p-cresol)	4.62E-02	3.46E-07	0.03	7.15E-07	1.52E-05	4.33E-06	1.98E-06
110-86-1	Pyridine	7.22E-03	6.31E-08	0	6.26E-07	1.81E-05	3.95E-06	1.80E-06
16984-48-8	Fluoride	2.72E-01	2.26E-06	0.01	3.75E-07	2.63E-06	2.36E-06	1.08E-06
121-14-2	2, 4-Dinitrotoluene	7.52E-03	5.63E-08	0.03	2.81E-07	6.43E-06	1.76E-06	8.05E-07
95-57-8	2-Chlorophenol	1.04E-02	9.09E-08	0	1.91E-07	2.80E-06	1.14E-06	5.19E-07
95-50-1	o-Dichlorobenzene	1.07E-02	8.05E-08	0.03	1.51E-07	2.18E-07	1.12E-07	5.11E-08
108-39-4	m-Cresol (3-Methylphenol)	4.62E-02	3.46E-07	0.03	7.27E-08	1.51E-06	4.33E-07	1.98E-07
106-46-7	1, 4-Dichlorobenzene	1.04E-02	7.76E-08	0.03	6.51E-08	2.23E-07	3.24E-07	1.48E-07
67-66-3	Chloroform	6.11E-05	5.34E-10	0	6.20E-08	7.13E-08	6.68E-09	3.05E-09
79-01-6	1, 1, 2-Trichloroethylene	8.12E-05	6.76E-10	0.01	3.56E-08	1.72E-07	2.82E-07	1.29E-07
95-48-7	2-Methylphenol (o-cresol)	2.03E-02	1.52E-07	0.03	3.19E-08	6.81E-07	1.90E-07	8.69E-08
120-82-1	1, 2, 4-Trichlorobenzene	6.47E-05	3.59E-10	0.1	3.16E-08	3.69E-08	6.89E-09	2.76E-09
107-06-2	1, 2-Dichloroethane	4.17E-05	3.64E-10	0	2.58E-08	2.92E-08	1.52E-09	6.94E-10
87-86-5	Pentachlorophenol	5.19E-03	3.89E-08	0.03	2.10E-08	1.06E-07	3.48E-07	1.39E-07
79-46-9	2-Nitropropane	1.01E-04	8.81E-10	0	1.53E-08	1.68E-08	NDF	NDF
56-23-5	Carbon tetrachloride	7.61E-05	6.66E-10	0	1.04E-08	6.56E-08	1.19E-07	5.43E-08
108-95-2	Phenol	2.36E-02	1.96E-07	0.01	6.56E-09	2.16E-07	4.09E-08	1.87E-08
71-43-2	Benzene	4.04E-05	3.36E-10	0.01	4.76E-09	1.03E-08	1.05E-08	4.80E-09
1330-20-7	Xylenes	1.52E-04	1.26E-09	0.01	4.44E-09	5.25E-09	7.89E-10	3.61E-10

Table 2. Hazardous Chemicals Contributors to C-106 Hazard Index

CASRN	Analyte Name	Total Inventory (Kg)	Concentration (mg/L)	Kd Bin (mL/g)	HSRAM HQ Industrial	HSRAM HQ Residential	MTCA B HQ Residential	MTCA C HQ Industrial
78-83-1	Isobutanol	1.44E-02	1.26E-07	0	4.15E-09	6.15E-08	2.62E-08	1.20E-08
95-95-4	2, 4, 5-Trichlorophenol	5.55E-03	3.08E-08	0.1	4.09E-09	2.92E-08	1.93E-08	8.80E-09
108-38-3	m-Xylene	1.15E-04	9.56E-10	0.01	3.37E-09	3.98E-09	5.98E-10	2.73E-10
7440-61-1	Uranium	1.47E+00	1.93E-10	0.6	3.19E-09	2.23E-08	2.01E-08	9.20E-09
110-80-5	2-Ethoxyethanol	5.67E-03	4.96E-08	0	2.86E-09	6.66E-08	7.75E-09	3.54E-09
108-90-7	Chlorobenzene	4.99E-05	4.15E-10	0.01	2.71E-09	4.22E-09	2.60E-09	1.19E-09
83-32-9	Acenaphthene	1.19E-02	6.22E-09	0.3	2.47E-09	1.01E-08	8.32E-09	3.33E-09
75-01-4	Chloroethene(vinyl chloride)	2.90E-05	2.53E-10	0	1.73E-09	7.01E-09	1.06E-08	4.83E-09
75-35-4	1, 1-Dichloroethene	6.82E-05	5.68E-10	0.01	1.10E-09	1.87E-09	1.42E-09	6.49E-10
95-47-6	o-Xylene	3.59E-05	2.69E-10	0.03	9.46E-10	1.12E-09	1.68E-10	7.68E-11
79-00-5	1, 1, 2-Trichloroethane	4.22E-05	3.51E-10	0.01	8.82E-10	6.76E-09	1.10E-08	5.02E-09
127-18-4	Tetrachloroethylene	5.31E-05	4.42E-10	0.01	7.59E-10	3.34E-09	5.53E-09	2.53E-09
100-41-4	Ethylbenzene	1.01E-04	8.39E-10	0.01	3.93E-10	9.20E-10	1.05E-09	4.79E-10
108-88-3	Toluene	4.75E-05	3.96E-10	0.01	3.66E-10	5.18E-10	2.47E-10	1.13E-10
75-15-0	Carbon disulfide	5.97E-05	5.21E-10	0	3.13E-10	6.50E-10	6.52E-10	2.98E-10
108-94-1	Cyclohexanone	1.72E-02	1.50E-07	0	2.97E-10	6.34E-09	1.88E-09	8.60E-10
75-69-4	Trichlorofluoromethane	6.01E-05	5.01E-10	0.01	2.68E-10	3.91E-10	2.09E-10	9.53E-11
106-42-3	p-Xylene	1.15E-04	5.99E-11	0.3	2.11E-10	2.49E-10	3.74E-11	1.71E-11
108-10-1	4-Methyl-2-pentanone (MIBK)	8.66E-05	7.21E-10	0.01	1.73E-10	9.08E-10	1.13E-09	5.15E-10
75-09-2	Dichloromethane	4.94E-05	4.32E-10	0	1.21E-10	6.04E-10	9.00E-10	4.11E-10
71-55-6	1, 1, 1-Trichloroethane	5.76E-05	4.80E-10	0.01	9.31E-11	2.01E-10	2.14E-10	9.79E-11
79-34-5	1, 1, 2, 2-Tetrachloroethane	4.22E-05	3.52E-10	0.01	5.98E-11	4.52E-10	7.33E-10	3.35E-10
60-29-7	Diethyl ether	5.66E-05	4.95E-10	0	2.45E-11	2.03E-10	3.09E-10	1.41E-10
141-78-6	Ethyl Acetate	6.31E-05	5.52E-10	0	6.04E-12	6.75E-11	3.83E-11	1.75E-11
76-13-1	1, 1, 2-Trichloro-1, 2, 2-trifluoroethane	6.48E-05	3.60E-10	0.1	4.28E-12	5.37E-12	7.49E-13	3.42E-13
7440-39-3	Barium	1.64E+00	0	>1	0	0	0	0
7440-43-9	Cadmium	1.44E+00	0	>1	0	0	0	0
57-12-5	Cyanide	7.82E-02	0	>1	0	0	0	0
7439-97-6	Mercury	1.93E+00	0	>1	0	0	NDF	NDF
7440-02-0	Nickel	3.02E+01	0	>1	0	0	0	0

Table 2. Hazardous Chemicals Contributors to C-106 Hazard Index

CASRN	Analyte Name	Total Inventory (Kg)	Concentration (mg/L)	Kd Bin (mL/g)	HSRAM HQ Industrial	HSRAM HQ Residential	MTCA B HQ Residential	MTCA C HQ Industrial
7440-22-4	Silver	7.85E+00	0	>1	0	0	0	0
7440-66-6	Zinc	2.13E+00	0	>1	0	0	0	0
7429-90-5	Aluminum	3.83E+02	0	>1	0	0	0	0
7440-50-8	Copper	2.31E+00	0	>1	0	0	0	0
7439-89-6	Iron	2.07E+02	0	>1	0	0	0	0
7439-96-5	Manganese	5.50E+02	0	>1	0	0	0	0
7723-14-0	Phosphorus	2.94E+01	0	>1	0	0	0	0
7440-24-6	Strontium	1.83E+00	0	>1	0	0	0	0
7440-38-2	Arsenic	1.45E+00	0	>1	0	0	0	0
7440-41-7	Beryllium	2.83E-02	0	>1	0	0	0	0
7782-49-2	Selenium	1.47E+00	0	>1	0	0	0	0
7440-28-0	Thallium	3.54E+00	0	>1	0	0	0	0
7440-62-2	Vanadium	1.47E-01	0	>1	0	0	0	0
85-68-7	Butylbenzylphthalate	2.12E-03	0	>1	0	0	0	0
117-84-0	Di-n-octylphthalate	1.19E-02	0	>1	0	0	0	0
206-44-0	Fluoranthene	7.18E-03	0	>1	0	0	0	0
87-68-3	Hexachlorobutadiene	2.65E-03	0	>1	0	0	0	0
67-72-1	Hexachloroethane	3.80E-05	0	>1	0	0	0	0
129-00-0	Pyrene	1.15E-02	0	>1	0	0	0	0
7440-36-0	Antimony	5.95E-01	0	>1	0	0	0	0
7440-42-8	Boron	5.95E-01	0	>1	0	0	0	0
7439-93-2	Lithium	5.65E-02	0	>1	0	0	0	0
7439-98-7	Molybdenum	1.53E-01	0	>1	0	0	0	0
7440-31-5	Tin	1.21E+00	0	>1	0	0	0	0
7440-38-2	Arsenic	1.45E+00	0	>1	0	0	0	0
Total Hazard Index					1.65E-04	9.81E-04	1.00E-03	4.11E-04

Footnotes: ¹Total Inventory by constituent in the tank residual waste.²Concentration of contaminants and/or risk associated with concentration of contaminants in groundwater at the Waste Management Area fence line.
"0" denotes that contaminants were not present in groundwater at the Waste Management Area fence line.

No-shade in cells are detected analytes; Shaded cells are non-detected analytes with inventory calculated at $\frac{1}{2}$ the detection limit, red analytes are analytes identified in the DQO as secondary, all others were identified as primary.

NSF = No slope factor for ingestions for incremental lifetime cancer risk.

Detection limits for analytes provided in RPP-20577 Rev. 0, Stage II Retrieval Data Report.