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Title/Desc:
TOXIC CHEMICAL CONSIDERATIONS FOR TANK FARM RELEASES [SEC 2 OF 2]

Pages: 146

This document was too large to scan as a whole document, therefore it required breaking into smaller sections.

DOCUMENT NUMBER: WM-SARR-011

SECTION 2 OF 2

TITLE: Tank Farm Accelerated Safety

DATE: 11/20-95

ORIGINATOR: G A Chaffee

CO:

RECIPIENT:

CO:

REFERENCES:

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CONTROLLED MANUAL WAIVER REQUEST

Date Prepared 5/11/94 Waiver Request Number WA-517

Affected Document Identification WHC-CM-4-46, "Nonreactor Facility Safety Analysis Manual"

Requirements Being Waived Company policy on toxic chemical risk guidelines in Section 7, Subsections 3.2 and 4.2 (Attachment 1)

Description of Requested Waiver Request approval to use Westinghouse corporate acute risk guidelines for toxic chemicals and associated guidance in place of those currently in WHC-CM-4-46. Approval of this waiver request would allow use of guidelines that are more technically justifiable than those currently in WHC-CM-4-46.

Since issuance of the existing toxic chemical risk guidelines, it has been determined that (a) interpolation between guideline values is not appropriate, (b) there are better alternate values to use in place of nonexistent chemical guideline values, (c) an additional guideline should be used for offsite risk guidelines, and (d) more detailed guidance is required to perform toxic chemical release analyses appropriately. These determinations resulted from work by the Westinghouse M&O Nuclear Facility Safety Subcommittee on Nonradiological Risk Acceptance Guidelines Development, documented in WSRC-MS-92-206[1] (available upon request from Janet S. Davis at 376-9284).

Suggested revisions to WHC-CM-4-46 to incorporate these changes have been submitted to Safety Standards and Requirements (Attachments 2 and 3). Attachment 2 is the proposed revision for Subsections 3.2 and 4.2 of Section 7.0 of WHC-CM-4-46. Attachment 3 is the proposed revision to Appendix D of WHC-CM-4-46, which is an expansion of the existing Appendix D.[2]

This waiver is being requested for the Tank Farms Accelerated Safety Analysis effort. The waiver will be in effect until a formal revision is made to WHC-CM-4-46.

Requesting Organization Criticality & Radiological Analyses

Requesting Organization Contact Janet S. Davis (376-9284)

Responsible Organization Nuclear Safety Standards & Requirements

Responsible Organization Interpretive Authority Jerry L. Rathbun (372-2771)

Brief Description of Affected Documents and Impacts (if applicable) Not applicable

[1] Douglas K. Craig, et al., "Toxic Chemical Hazard Classification and Risk-Acceptance Guidelines for Use in DOE Facilities - Recommendations of the Westinghouse M&O Nuclear Facility Safety Committee Subcommittee on Nonradiological Risk Acceptance Guidelines Development," WSRC-MS-92-206, Rev. 1, April 20, 1993.

[2] A waiver from the existing Appendix D is not being requested because the existing Appendix D merely provides definitions of Emergency Response Planning Guideline (ERPG) levels. The suggested revision to Appendix D includes guidance on what values to use when ERPG values are nonexistent.

Signatures: Requesting Organization and Manual Approval Authority signatures are mandatory.

REQUESTING ORGANIZATION

Originator: Janet S. Davis — Date 5/11/94

Organization: Criticality & Radiological Analyses

Approved by: J W Daughtry — Date 5/19/94

Cognizant Level 3 Manager — James W. Daughtry

MANUAL APPROVAL AUTHORITY

DMBrock 5/26/94

Approved by: J L Rathbun — Date 5/27/94

Interpretive Authority — Jerry L. Rathbun

Approved by: Leslie L. Reed — Date 5/27/94

Level 2 Manager, Responsible Organization — Leslie L. Reed

OTHER APPROVALS (As Required)

Approved by: NA — Date

Contracts Administration
(Only when DOE Directives are involved)

Approved by: NA — Date

President's Office
(Required for requests involving DOE Directives
or Level I WHC Controlled Manuals)

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WESTINGHOUSE HANFORD COMPANY	Manual	WHC-CM-4-46
	Section	7.0, REV 3
	Page	1 of 7
NONREACTOR FACILITY SAFETY ANALYSIS MANUAL	Effective Date	November 26, 1993
	Organization	ESQ/Nuclear Safety
TITLE:	Approved by	
RISK	G. L. Rathbun, Acting Manager Nuclear Safety	10/27/93

1.0 PURPOSE

Risk is a quantitative or qualitative expression of possible loss which considers both the probability that a hazard will cause harm and the consequences of that event. This chapter defines radiological and nonradiological acceptable risk guidelines for the evaluation of accident analyses.

2.0 SCOPE

This chapter applies to all U.S. Department of Energy (DOE) activities and nonreactor facilities managed by Westinghouse Hanford Company (WHC) for which a safety analysis is required.

3.0 REQUIREMENTS

The safety analysis shall demonstrate that there is a reasonable assurance that DOE operations and activities can be conducted in a manner that will limit risks to the health and safety of the public and employees, and adequately protect the environment.

Radiological and nonradiological consequences of all safety analyses must be evaluated with respect to the acceptable risk guidelines presented in this chapter, and documented in the appropriate section(s) of the safety analysis report (e.g., PSE, PSAR, FSAR, safety assessment, etc.).

3.1 Radiological Risk Comparison Guidelines

The radiological risk acceptance guidelines apply to doses which would result from direct exposure to the passing plume (i.e, inhalation and submersion). Potential effects resulting from secondary exposure (e.g., ingestion of contaminated food, exposure to contaminated soils, etc.) must also be evaluated. This evaluation may be in terms of potential ingestion doses or estimates of the extent of ground contamination. In general, the risk of these secondary effects will be acceptable if potential ground contamination levels are not large enough to warrant a safety class 1 confinement system, or if potential ingestion doses are not large enough to require interdiction of food or impoundment of land.

Figure 7-1 defines offsite and onsite radiological risk comparison guidelines for all credible frequencies. If the event sequence is qualitatively categorized as 'anticipated,' 'unlikely,' or 'extremely unlikely,' the associated consequences must be shown by analysis to be bounded in the corresponding ranges. If a single point estimate is used to report potential consequences, the value must be equal to or less than the lowest value in the corresponding probability range.

3.2 Nonradiological Risk Acceptance Guidelines

Table 2 presents the guidelines to be used in the determination of risk for nonradiological releases. These guidelines should be applied as continuous curves, as illustrated in Figure 7-2 for chlorine. If the event sequence is qualitatively categorized as 'anticipated,' 'unlikely,' or 'extremely unlikely,' the associated consequences must be shown by analysis to be bounded in the corresponding ranges. If a single point estimate is used to report potential consequences, the value must be equal to or less than the lowest value in the corresponding probability range.

4.0 PROCEDURE

4.1 Radiological Evaluation of Risk.

STEP 1. Identify the frequency of the event sequence and radiological consequence for the maximum onsite and the maximum offsite individuals for each accident scenario.

STEP 2. Compare the values to either Figure 7-1 and/or Table 1 as appropriate to determine if the risk is acceptable. If the risk is below the corresponding acceptable risk guideline, the risk presented by the event sequence will generally be considered acceptable. However, the risk associated with the operation of any facility will be formally accepted on an individual, case-by-case basis.

If the event sequence is qualitatively categorized as 'anticipated,' 'unlikely,' or 'extremely unlikely,' the associated consequences must be shown by analysis to be equal to or less than the lowest dose value in the corresponding probability range.

Compare the consequences and frequency determined in the accident analysis to the risk acceptance guidelines to determine if the risk is acceptable. Risk is generally considered to be acceptable if the consequences and/or frequency of the accident do not exceed the risk acceptance guidelines.

ATTACHMENT 1

STEP 3 If the risk is determined to be unacceptable, the accident scenario(s) should be reevaluated to eliminate excess conservatisms, utilizing the tools and techniques discussed in Chapter 2.0 of this manual.

STEP 4 At the point that risk is verified as unacceptable and excessive conservatisms removed, management needs to be notified, plant designs reevaluated to consider additional preventive or mitigative features, and perhaps new procedures and administrative controls implemented to reduce the risk.

4.2 Nonradiological Evaluation of Risk

STEP 1 Identify the annual probability of the event and nonradiological exposure concentration for each accident scenario.

STEP 2 Obtain the most current ERPG values[1] from HEHF.

STEP 3 Compare the consequences determined in the accident analysis to the chemical-specific concentration guidelines to determine if the risk is acceptable. Concentration guidelines are obtained from curves developed for each chemical using the ERPG values in Table 2. Risk is generally considered to acceptable if the consequences of the accident do not exceed the concentration guidelines associated with the frequency of the event sequence. Appendix D contains additional information on ERPGs.

If the event sequence is qualitatively categorized as 'anticipated,' 'unlikely,' or 'extremely unlikely,' the associated consequences must be shown by analysis to be equal to or less than the lowest exposure concentration value in the corresponding probability range.

ERPG-1 values do not exist for all chemicals. In the event that there is no ERPG-1 concentration, and one cannot be developed by HEHF, the chemicals Threshold Limit Value - Time Weighted Average (TLV-TWA) should be used in the comparison. When comparing calculated concentrations to a TLV-TWA or ERPG, normalize the average concentration over a period of 8 hours and 1 hour, respectively for comparison purposes.

STEP 4 If the risk is determined to be unacceptable, the accident scenario(s) should be reevaluated to eliminate excess conservatisms, utilizing the tools and techniques discussed in Chapter 2.0 of the this manual.

[1] See Appendix D for definitions of ERPG-1, ERPG-2, and ERPG-3; also see Appendix A, "Glossary."

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STEP 5 At the point that risk is verified as unacceptable and excessive conservatisms removed, management needs to be notified, plant designs reevaluated, and perhaps new procedures and administrative controls implemented to reduce the risk.

Table 1 Radiological Risk Acceptance Guidelines[2]

Frequency Category[3]	Frequency Range	Effective Dose Equivalent (rem)	Organ Dose Equivalent for Lens of Eye (rem)	Organ Dose Equivalent for ALL Other Organs (rem)
Offsite Guidelines				
Anticipated	1 - 10^{-2}	0.01 - 0.5	0.03 - 1.5	0.1 - 5
Unlikely	10^{-2} - 10^{-4}	0.5 - 4	1.5 - 12	5 - 40
Extremely Unlikely	10^{-4} - 10^{-6}	4 - 25	12 - 75	40 - 250
Onsite Guidelines				
Anticipated	0.1 to 10^{-2}	1 to 5	3 - 15	10 - 50
Unlikely	10^{-2} to 10^{-4}	5 - 25	15 - 75	50 - 250
Extremely Unlikely	10^{-4} to 10^{-6}	25 - 100	75 - 300	250 - 1000

[2] These guidelines are to be applied as curves as shown in Figure 7-1, EDE Values. To determine corresponding organ dose equivalents that must also be met, multiply the EDE value by 3 to obtain the limit for the lens of the eye and multiply by 10 to obtain the limit for all other organs.

[3] See Appendix B for additional definitions of the probability categories.

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Table 2 Nonradiological Risk Acceptance Guidelines[4]		
Frequency	Concentration[5]	
	Onsite	Offsite
1 to 10^{-6}	ERPG-2 to ERPG-3	ERPG-1 to ERPG-2

[4] These guidelines are to be applied as curves, as demonstrated in Figure 7-2.

[5] ERPG values may be obtained from the Hanford Environmental Health Foundation.

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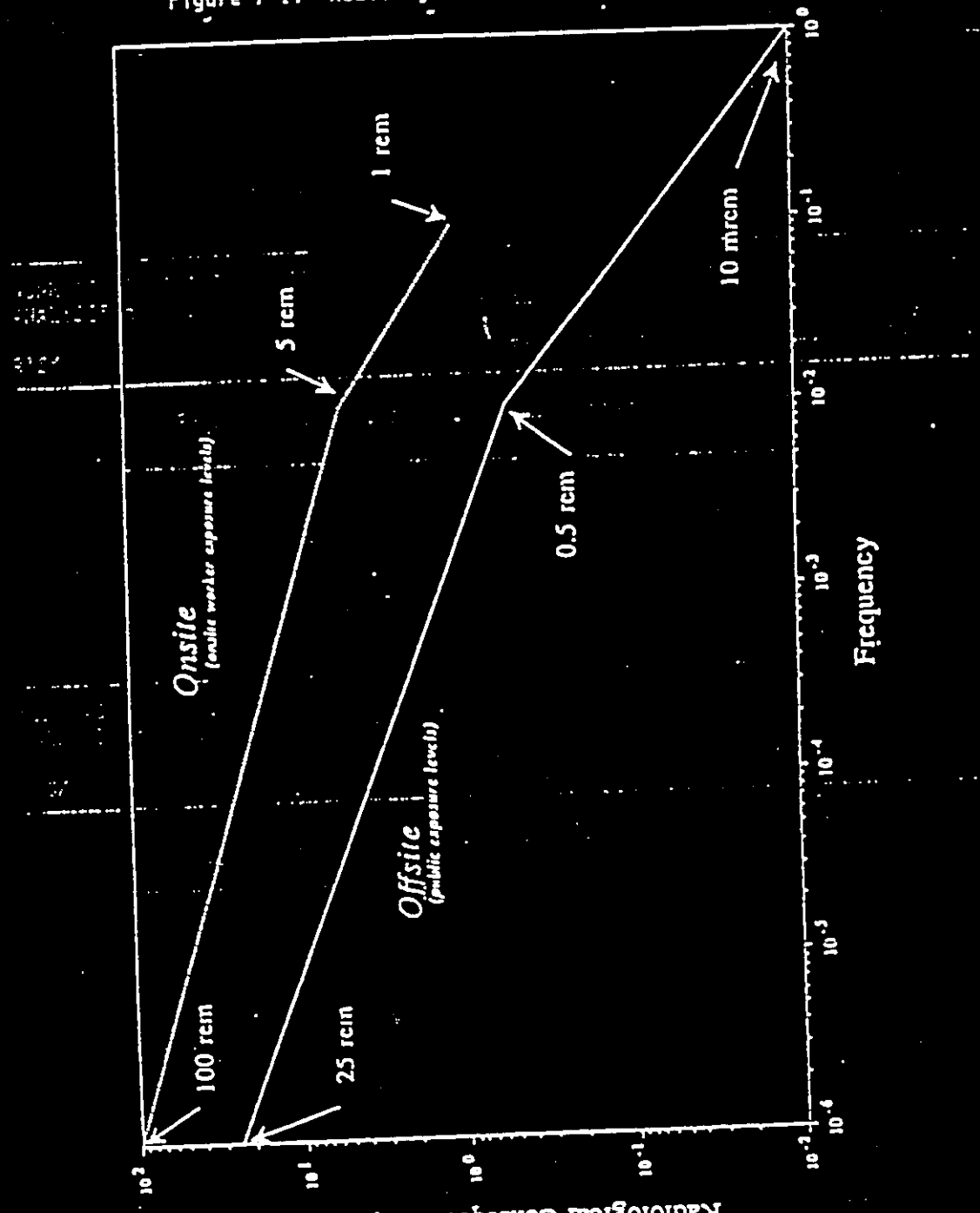
Figure 7-1. Radiological Risk Comparison Guidelines



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NONREACTOR FACILITY SAFETY ANALYSIS MANUAL	Manual	WHC-CM-4-46
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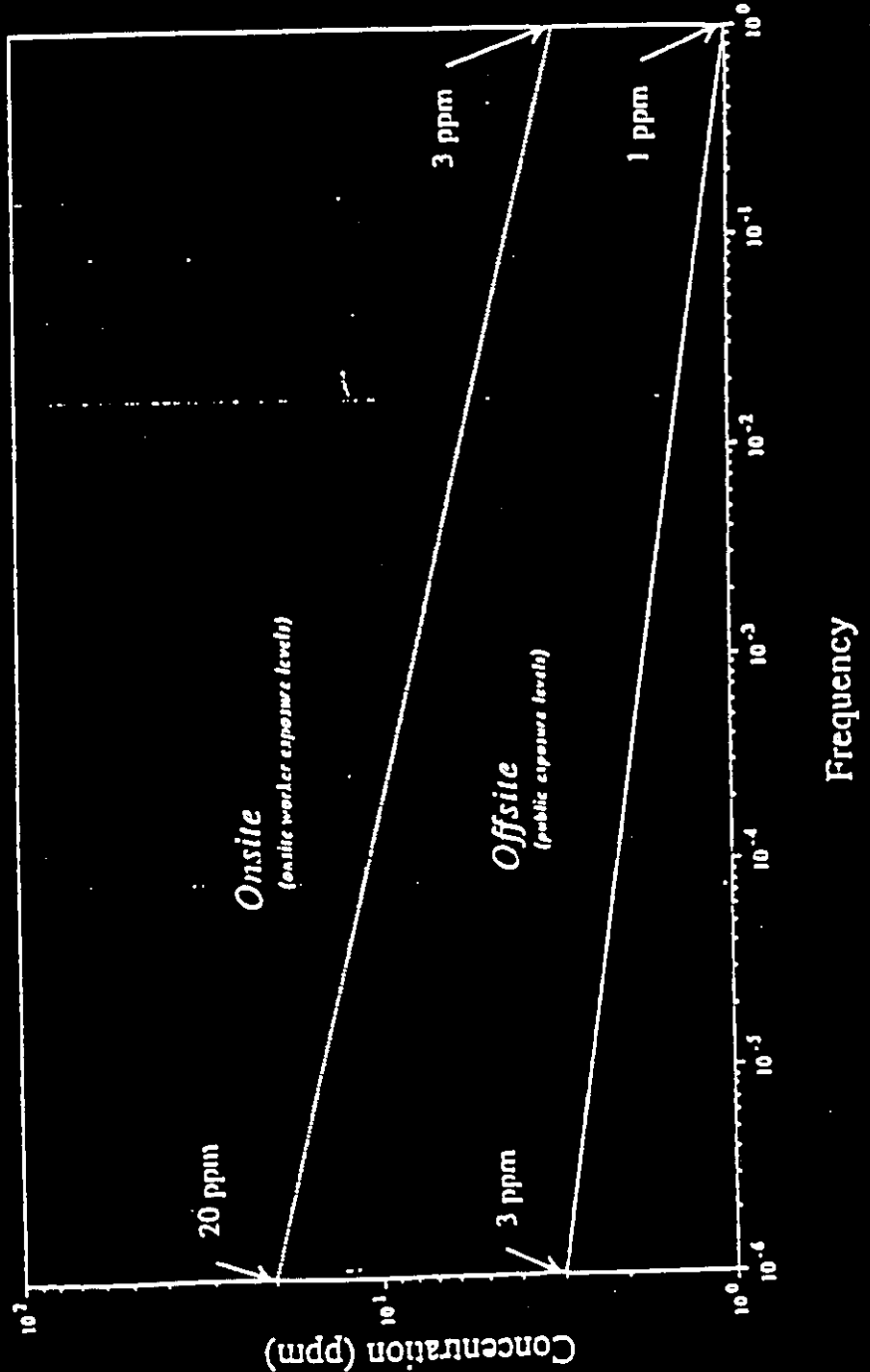
	Page	7 of 7
RISK	Effective Date	November 26, 1993

Figure 7-2. Chlorine Risk Comparison Guidelines



ATTACHMENT 2

April 12, 1994

The purpose of the attached suggested revision to WHC-CM-4-46 Section 7.0 is to:

a. Provide toxic chemical risk guidelines consistent with the Westinghouse M&O recommendations on this subject and consistent with guidelines being used by other Westinghouse M&O contractors,

b. Provide guidance on how to calculate consequences for comparison with the risk guidelines,

c. Eliminate guidance to normalize resulting chemical concentrations over the time period associated with the risk guideline,

d. Provide guidance on the time period over which consequences should be normalized,

e. Eliminate the correlation between ERPG-1 and TLV-TWA,

f. Appropriately refer to Appendix D in its new form (assuming that the suggested revision for Appendix D will be implemented, with its listing of what values to use if ERPG values are not available),

g. Replace the term "annual probability" with "annual frequency," and

h. Make other minor editorial changes in terminology.

The suggested revisions are listed in the following pages. Where quotes are made, capital letters indicate suggested changes (except for acronyms, which are normally capitalized anyway).

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SUGGESTED REVISION TO WHC-CM-4-46 TOXIC CHEMICAL RISK GUIDELINES

1. Table 2 of Section 7.0, "Nonradiological Risk Acceptance Guidelines," should be replaced with the following table, and the title should be changed to "Toxic Chemical Risk Guidelines." (I've deleted the word "acceptance" in "risk acceptance guidelines" throughout this transmittal because it is superfluous):

		PRIMARY CONCENTRATION GUIDELINES	
EVENT FREQUENCY CATEGORY	EVENT FREQUENCY (YR^{-1})	ONSITE	OFFSITE
Anticipated	$>10^{-2}$ to $\leq 10^{-1}$	≤ERPG-1	≤PEL-TWA
Unlikely	$>10^{-4}$ to $\leq 10^{-2}$	≤ERPG-2	≤ERPG-1
Extremely Unlikely	$>10^{-6}$ to $\leq 10^{-4}$	≤ERPG-3	≤ERPG-2

2. Replace Subsection 3.2 of Section 7.0 (repeated here for information):

> "Table 2 presents the guidelines to be used in the determination of risk for nonradiological releases. These guidelines should be applied as continuous curves, as illustrated in Figure 7-2 for chlorine. If the event sequence is qualitatively categorized as 'anticipated,' 'unlikely,' or 'extremely unlikely,' the associated consequences must be shown by analysis to be bounded in the corresponding ranges. If a single point estimate is used to report potential consequences, the value must be equal to or less than the lowest value in the corresponding probability range."

[Replace Subsection 3.2 of Section 7.0] with:

> "Table 2 presents the guidelines to be used in the determination of risk for TOXIC CHEMICAL releases. THESE GUIDELINES SHOULD BE APPLIED AS STEP FUNCTIONS, AS ILLUSTRATED IN FIGURE 7-2 FOR CHLORINE. THESE GUIDELINES APPLY TO THE AIRBORNE PATHWAY ONLY."
>
> [The sentences addressing qualitative frequency categorization are eliminated because the new guidelines are in the form of a step function. This eliminates the concept of the "lowest value in the corresponding probability range."]

3. Step 1 of Subsection 4.2: Replace the Step 1 paragraph with the following paragraphs to (a) replace "probability" with "frequency," (b) clarify the consequences to be calculated, (c) add information on how to

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calculate the consequences, and (d) provide background information on why certain guidance has been provided.

"DETERMINE the annual FREQUENCY AND/OR FREQUENCY CATEGORY of the event and CALCULATE THE HYPOTHETICAL CHEMICAL CONCENTRATIONS AT THE RECEPTOR LOCATIONS OF CONCERN. (SEE APPENDIX D FOR A DISCUSSION OF SCREENING OF CHEMICALS TO DETERMINE WHICH CHEMICALS SHOULD BE EVALUATED.)

"CONCENTRATIONS FOR COMPARISON WITH THE GUIDELINES MUST BE CALCULATED AS THE PEAK 15-MINUTE AVERAGE CONCENTRATIONS (REFERENCE A). THIS IS APPLICABLE FOR ALL CHEMICALS FOR WHICH THE TOXIC EFFECT IS IMMEDIATE, (I.E., CONCENTRATION-DEPENDENT). IF IT IS KNOWN THAT THE TOXIC EFFECTS OF A CHEMICAL ARE NOT CONCENTRATION-DEPENDENT, BUT DEPEND ON THE TOTAL QUANTITY OF CHEMICAL TAKEN UP BY THE BODY (I.E., DOSE-DEPENDENT), THEN THE PEAK 1-HOUR CONCENTRATION MAY BE USED.

"CONCENTRATION-DEPENDENT CHEMICALS ARE DEFINED AS FAST-ACTING CHEMICALS WHOSE TOXIC EFFECTS ARE IMMEDIATE, AND CORRELATE MORE CLOSELY TO CONCENTRATION THAN DOSE. INCLUDED IN THIS CATEGORY ARE SENSORY IRRITANTS AND CHEMICALS WHICH ARE CORROSIVE OR CAUSE BLISTERING OF TISSUE. ANY CHEMICAL WHICH HAS BEEN ASSIGNED AN OSHA PEL-STEL OR PEL-C, OR AN ACGIH TLV-STEL OR TLV-C VALUE MUST BE CONSIDERED CONCENTRATION-DEPENDENT. IN CONTRAST, THE EFFECTS OF DOSE-DEPENDENT CHEMICALS ARE A FUNCTION OF BOTH CONCENTRATION AND DURATION OF EXPOSURE.

"ATMOSPHERIC MODELS APPROPRIATE FOR THE SITE AND/OR ACCIDENT SCENARIO BEING EVALUATED SHOULD BE USED (E.G., DENSE GAS MODEL, BUOYANT PLUME MODEL, STRAIGHT-LINE GAUSSIAN PLUME MODEL, ETC.) SO THAT A CONSERVATIVE RISK ASSESSMENT IS PERFORMED. BUILDING WAKE EFFECTS MAY BE CONSIDERED, BUT PLUME MEANDER SHOULD NOT BE CONSIDERED. (PLUME MEANDER CORRECTIONS ARE NOT CONSIDERED FOR CHEMICAL RELEASES BECAUSE THEY CAN ARTIFICIALLY MASK HIGHER CONCENTRATIONS. THIS HAPPENS BECAUSE A PLUME MEANDER CORRECTION ACCOUTNS FOR THE "MEANDERING" OF A PLUME WITHIN A 22.5-DEGREE SECTOR. CONCEPTUALLY THIS HAS THE EFFECT OF EXPOSING THE CENTERLINE RECEPTOR TO THE PLUME INTERMITTENTLY. HOWEVER, SINCE THE MATHEMATICAL MODEL FOR PLUME MEANDER AVERAGES THE CONCENTRATION OVER THE ENTIRE SECTOR, THE CONCENTRATION THAT THE RECEPTOR ACTUALLY SEES IS LOWERED (MASKED) TO AN AVERAGE, CONTINUOUS CONCENTRATION. THIS IS APPROPRIATE FOR RADIOLOGICAL DOSES BECAUSE RADIOLOGICAL EXPOSURE IS INTEGRATED OVER TIME. HOWEVER, SINCE EXPOSURE TO CHEMICAL RELEASES IS NOT INTEGRATED, THE PLUME MEANDER CORRECTION IS NOT APPLICABLE TO CHEMICAL RELEASES."

Reference A: Douglas K. Craig, et al., "Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities - Recommendations of the Westinghouse M&O Nuclear Facility Safety Committee Subcommittee on Nonradiological Risk

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Acceptance Guidelines Development" WSRC-MS-92-206, Rev. 1, April 20, 1993.

4. Step 2 of Section 4.2: Delete Footnote 1, and add the deleted information to a sentence following the existing sentence.

"Obtain the most current ERPG values from HEHF. SEE APPENDIX D FOR DEFINITIONS OF THE THREE ERPG VALUES AND VALUES TO USE IF ERPGs ARE NOT AVAILABLE."

5. Step 3 of Section 4.2:

Add the following to Paragraph 1:

"... Appendix D contains additional information on ERPGs AND VALUES TO USE IF ERPGs ARE NOT AVAILABLE."

Delete Paragraph 3 (quoted here for information):

"ERPG-1 values do not exist for all chemicals. In the event that there is no ERPG-1 concentration, and one cannot be developed by HEHF, the chemicals Threshold Limit Value - Time Weighted Average (TLV-TWA) should be used in the comparison. When comparing calculated concentrations to a TLV-TWA or ERPG, normalize the average concentration over a period of 8 hours and 1 hour, respectively for comparison purposes."

[Paragraph 3 is deleted because (a) the values to use when ERPGs are not available are discussed in the new Appendix D, and (b) the time periods over which concentration averaging should occur are discussed in the new Step 1 of Subsection 4.2.]

6. The existing Figure 7.2 (illustrating the continuous curve concept) should be replaced with the attached new Figure 7.2 illustrating the step function concept.

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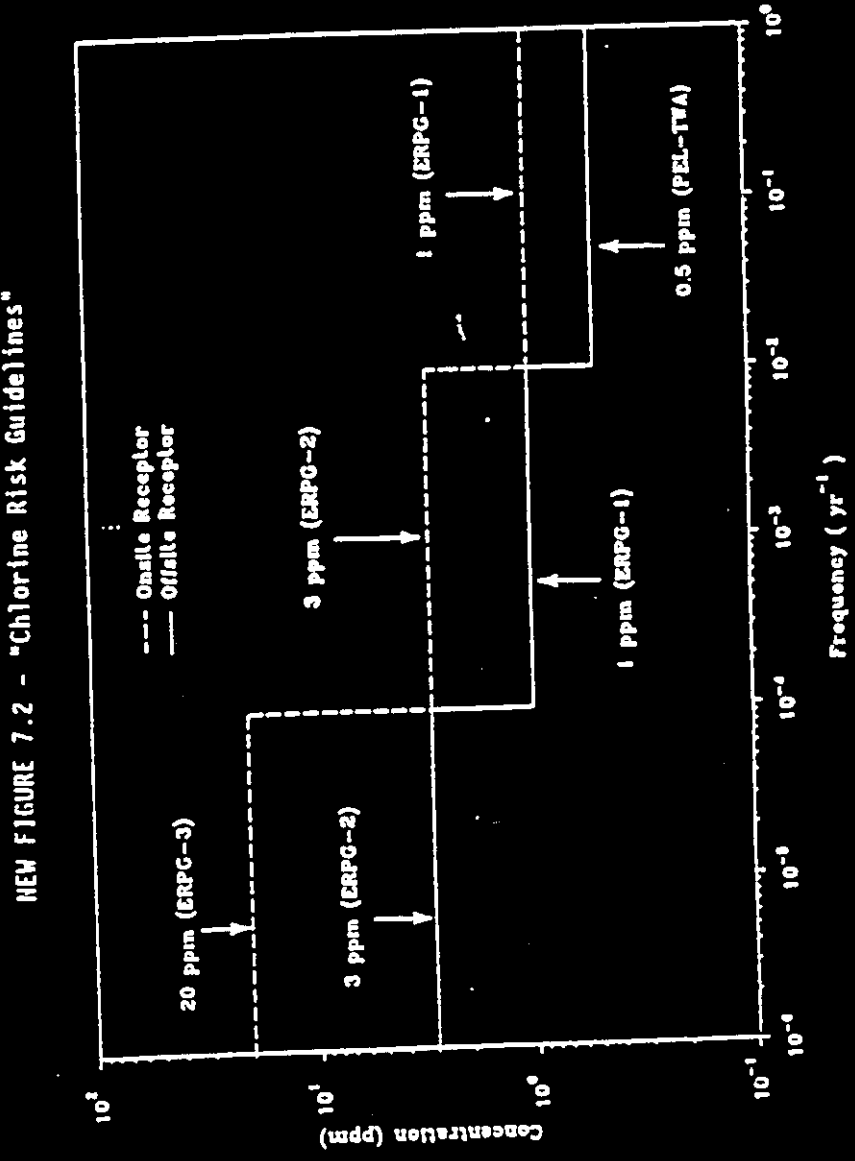

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ATTACHMENT 3

PROPOSED REVISION 1 OF APPENDIX D OF WHC-CM-4-46

ERPG DEFINITIONS AND RECOMMENDED ALTERNATE TOXIC CONCENTRATION GUIDELINES TO BE USED FOR HAZARD CLASSIFICATION, RISK ASSESSMENT, AND SAFETY CLASSIFICATION

J.S. Davis 11/15/93

Note: Acronym definitions are provided in Attachment 1 of this appendix.

DEFINITION OF ERPGs AND WHERE TO FIND SPECIFIC VALUES

ERPGs (Emergency Response Planning Guidelines), as developed by the American Industrial Hygiene Association, are based on an up-to-1-hour, once-in-a-lifetime potential exposure to the general population. The values are intended as estimates of concentration ranges where there is a reasonable probability of adverse effects from exposure to the specific chemical. The adverse effects associated with each of the ERPG levels are (from Reference 3):

> "The ERPG-1 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.
>
> The ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.
>
> The ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing life-threatening health effects."

In the absence of ERPG values from American Industrial Hygiene Association, Hanford Environmental Health Foundation (HEHF) has been developing ERPGs for chemicals as requested. The AIHA and Hanford-developed values are available on HLAN in Hanford Information, under "Hanford Emergency Response Planning Guides for Chemicals." This file also contains names and phone numbers of HEHF personnel that can provide additional information.

WHAT TO DO IF THERE ARE NO ERPG VALUES FOR THE CHEMICAL OF INTEREST

This section provides alternate values and approaches for cases where ERPG values are not available for certain chemicals.

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The recommended alternate concentration guidelines in Table 1 are based on References 1 and 2. The protocol is to use the guidelines in Table 1 in the order presented, on the basis of availability for the chemical of interest.

TABLE 1. Recommended Alternate Concentration Guidelines

PRIMARY GUIDELINE	ALTERNATE GUIDELINE	SOURCE (REFERENCE NO.)
ERPG-3	EEGL (30 min)	AIHA (3)
	IDLH	NAS (4)
		NIOSH (5)
ERPG-2	EEGL (60 min)	AIHA (3)
	LOC	NAS (4)
	PEL-C	EPA/DOT/FEMA (6)
	TLV-C	OSHA (7)
	TLV-TWA x 5	ACGIH (8)
		ACGIH (8)
ERPG-1	PEL-STEL	AIHA (3)
	TLV-STEL	OSHA (7)
	TLV-TWA x 3	ACGIH (8)
		ACGIH (8)

AIHA- and Hanford-developed ERPGs are available on HLAN Hanford Information under Hanford Emergency Response Planning Guides for Chemicals.

If no concentration values are available for a given chemical, a knowledgeable individual (e.g., from HEHF) may be requested to (a) determine whether the chemical needs to be evaluated, (b) develop appropriate values, or (c) perform a case-specific examination that provides suitable justification for the conclusion. See Appendix 4 of Reference 1 for further guidance.

If no concentration values are available for a given chemical in the appropriate category, concentration values from the next most conservative (more restrictive) category may be used, in the order presented, on the basis of availability for the chemical of interest. For example, if the appropriate guideline is ERPG-3, and there are no values for an ERPG-3 or its alternates, the ERPG-2 and its alternate guidelines may be used. Documentation of determination of the chosen concentration should be provided. Note that this option is likely to be more limiting than the option of allowing a knowledgeable person to develop a value for the appropriate category.

A primary guideline may be developed by a knowledgeable individual if the value has not been published for the chemical of interest, even if values for the alternate guidelines have been published.

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DETERMINING IF A CHEMICAL NEEDS TO BE EVALUATED

The following questions should be addressed in determining whether a chemical hazard is significant enough to warrant consideration (Reference 1). It should be emphasized that this list is not all-inclusive and that it is possible that even though the answer to every one of the questions below is negative, the situation may warrant that a chemical be evaluated.

1. Is the chemical listed on any of the following:

   a. EPA's list of extremely hazardous substances having LOCs (6)?
   b. EPA's list of extremely hazardous substances and their TPQs (9)?
   c. EPA's list of hazardous substances and their RQs (10), or
   d. OSHA's list of highly hazardous chemicals, toxics and reactives and their TQs and DOE's addendum to this list (11)?

2. Have short-term exposure limits been derived for the chemical [e.g., ERPGs (3), PEL-STELs or PEL-Cs (7), TLV-STELs or TLV-Cs (8)]?

3. Is there any indication that the chemical exhibits significant toxic properties (12, 13)?

4. Is the chemical extremely reactive or flammable (14)?

5. Is the chemical in close physical proximity to incompatible chemicals (12, 14), which could result in the release of toxic reaction products in an accident (see applicable MSDS)?

6. What quantity of material is involved? Does the quantity exceed its TPQ (9), RQ (10), or TQ (11) value?

7. Is the material readily volatilized (i.e., coes it have a substantial vapor pressure at ambient temperatures)?

8. Does the material generate toxic combustion products (12)?

REFERENCES

1. D.K. Craig, et al., "Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities," WSRC-MS-92-206, Rev. 1. (Prepared by the Westinghouse Electric Corporation Management & Operations Contractors Subcommittee on Nonradiological Risk Criteria).

2. D.K. Craig, et al., "Chemical Exposures Working Group Recommendations to the Subcommittee on Consequence Assessment and Protective Actions (SCAPA) of the Emergency Managements Advisory Committee (EMAC)," transmitted via Letter, D.K. Craig (WSRC) to T. Tuccinardi (DOE-HQ), SRT-RAM-930170, October 4, 1993.

ATTACHMENT 3 Page 18 of 19

3. "Emergency Response Planning Guidelines," AIHA Emergency Response Planning Guideline Committee, American Industrial Hygiene Association, Akron, OH, 1991.

4. "Emergency and Continuous Exposure Guidance Levels for Selected Airborne Contaminants," V 1-7, Committee on Toxicology, Board on Toxicology and Environmental Health Standards, Commission on Life Sciences, National Research Council, National Academy Press, Washington, D.C., 1985.

5. "NIOSH Pocket Guide to Chemical Hazards," U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Washington, D.C., 1990.

6. "Technical Guidance for Hazard Analysis," Emergency Planning for Extremely Hazardous Substances, U.S. Environmental Protection Agency, Federal Emergency Management Agency, and U.S. Department of Transportation, USGPO 1991 517-003/47004, December 1987.

7. Code of Federal Regulations, Labor, 29 CFR Part 1910.1000, Subpart Z - Toxic and Hazardous Substances, pp 6-34 (7-1-91 edition).

8. 1991 - 1992 Threshold Limit Value for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, Cincinnati, OH, 1991.

9. Code of Federal Regulations, Protection of Environment, 40 CFR Part 355, Appendix A - Extremely Hazardous Substances and Their Threshold Planning Quantities.

10. Code of Federal Regulations, Protection of Environment, 40 CFR Part 302, Table 302.4 - List of Hazardous Substances and Reportable Quantities, pp 228-298 (7-1-91 Edition).

11. Code of Federal Regulations, Labor, 29 CFR Part 1910.119, Process Safety Management of Highly Hazardous Chemicals, Explosives and Blasting Agents, Final Rule. Appendix A - List of Highly Hazardous Chemicals, Toxics and Reactives, February 24, 1992.

12. N. Irving Sax, Dangerous Properties of Industrial Materials, 7th Edition (1991), Van Nostrand Reinhold Company, New York.

13. RTECS: Registry of Toxic Effects of Chemical Substances, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, April 1987. (Now available only as an online database.)

14. L. Bretherick, Handbook of Reactive Chemicals, 4th Edition (1990), Butterworths, Boston.

ATTACHMENT 3

ATTACHMENT 1

ACRONYM DEFINITIONS
(in alphabetical order)

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
CEGL	Continuous Exposure Guidance Level
DOT	Department of Transportation
EEGL	Emergency Exposure Guidance Level
EPA	Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
FEMA	Federal Emergency Management Agency
HEHF	Hanford Environmental Health Foundation
IDLH	Immediately Dangerous to Life and Health
LOC	Level of Concern
MSDS	Material Safety Data Sheet
NAS	National Academy of Sciences
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PEL-C	Permissible Exposure Limit - Ceiling
PEL-STEL	Permissible Exposure Limit - Short-Term Exposure Limit
PEL-TWA	Permissible Exposure Limit - Time-Weighted Average
RQ	Reportable Quantity
TLV-C	Threshold Limit Value - Ceiling
TLV-STEL	Threshold Limit Value - Short-Term Exposure Limit
TLV-TWA	Threshold Limit Value - Time-Weighted Average
TPQ	Threshold Planning Quantity
TQ	Threshold Quantity

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APPENDIX D.0

TOXICOLOGICAL EVALUATION OF TANK WASTE CHEMICALS

Dentler 1995
HEHF 1995

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HANFORD ENVIRONMENTAL
HEALTH FOUNDATION

CO 20436
CO 20848

January 17, 1995

Dr. John C. Van Keuren
Safety Analysis and Nuclear Engineering
Westinghouse Hanford Company
MSIN H4-64
Richland, Washington 99352

Dear Dr. Van Keuren:

A copy of the HEHF report titled, "Toxicological Evaluation of Tank Waste Chemicals," is attached. This report was generated by HEHF in response to WHC Letters of Instruction for the Services of Mitzi Dentler, LOI.M-8D150-94-001, May 19, 1994, Work Order EM4054 and LOI.M-8D150-95-002, October 12, 1994, Work Order EM5013. This work supports the Tank Farms Accelerated Safety Analysis (ASA).

A review of toxicological and industrial hygiene literature was conducted to determine which tank waste compounds identified in WHC-SD-WM-SARR-011, Rev. 0, "Toxic Chemical Considerations for Tank Farm Releases," pose an acute inhalation hazard for up to a one-hour exposure. Risk guidelines, including Permissible Exposure Limits and Emergency Response Planning Guidelines, were developed for the acutely hazardous compounds. The results of this review and the methods used to develop risk guidelines for the compounds of concern are detailed in the report.

Please contact me at 372-0532 or cc:Mail if you have any questions or if further assistance is needed.

Sincerely,

Mitzi L. Dentler, CIH
Hanford Environmental Health Foundation
Industrial Hygiene Assessments

MLD:rw

cc: *Janet S. Davis, H5-49
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TOXICOLOGICAL EVALUATION OF TANK WASTE CHEMICALS

M.L. Dentler, CIH
HEHF Industrial Hygiene Assessments
January 17, 1995

Requested by J.S. Davis and J.C. Van Keuren
WHC Criticality and Radiological Analyses
for Tank Waste Remediation Systems
Accelerated Safety Analysis

TOXICOLOGICAL EVALUATION OF TANK WASTE CHEMICALS

HEHF Industrial Hygiene Assessments

M.L. Dentler 01/13/95

1. Potential Tank Compounds Reviewed for Health Effects

The Hanford Environmental Health Foundation (HEHF) was requested by Westinghouse Hanford Company Safety Analysis and Engineering (WHC SAE) to review and evaluate chemicals known or expected to be present in tank waste. The purpose of the evaluation was to determine which chemicals posed a health hazard and should be considered in the tank farms accelerated safety analysis (ASA).20[1] A thorough search of toxicological and industrial hygiene references was performed for each compound noted in Appendix A, WORKING TABLE USED TO DETERMINE: (A) CHEMICAL COMPOUNDS IN TANK SOLIDS AND LIQUIDS, AND (B) WHICH COMPOUNDS REQUIRE RELEASE CONSEQUENCE ASSESSMENTS.[2] The degree of toxic, corrosive, or irritant effects from exposure by acute inhalation of aerosolized compounds was determined. Results of the determination were noted in the last column of the working table in App. A[3] as follows:

"Yes" Indicates the compound presents a significant health hazard under the conditions stated and should be included in the safety analysis; "

"No" Indicates the compound does not present a significant health hazard under the conditions stated, and should not be considered in the safety analysis as an individual compound.

However, all compounds are considered as contributors to the total aerosol mass of liquids and solids. This mass is referred to as "total particulate", and guidelines were developed for concentration limits needed to prevent mechanical interference with breathing (in addition to other health effects).

2. Compounds Grouped by Primary Health Effect

Based on the health effects review, compounds were placed into one of three mutually exclusive groups: toxics, corrosives and irritants, and contributors to total particulate only.[4] Compounds that fit in more than one group (i.e., both irritant and toxic) were grouped by either the most likely health effect that would be experienced or by the most severe. There was a general lack of quantitative data on the concentrations of irritants to define ERPG levels, so the irritants were grouped with the corrosives as a conservative measure. The moderate irritants can be separated into their own group, and higher and more realistic values developed for the group if further refinement is required.

3. Combining Compounds Within Groups

Compounds with similar health effects are considered additive; this includes chemicals that exhibit the same mechanism of action, target organ, or metabolic pathway. Due to time constraints, compounds with dissimilar toxic effects (different target organs or mechanisms of action, for example) were added within each group. The results are more conservative than placing the toxics into more similar subgroups for addition; this could be done later if a more realistic characterization of the toxic hazard is desired.

Each compound group is considered separately in the safety analysis (i.e., toxics are added together and corrosives and irritants are added together). The addition method is adapted from ACGIH and OSHA methods for adding combined exposures:

$$E_m = C_1/G_1 + C_2/G_2 + C_3/G_3 + C_4/G_4 + \ldots\ldots C_n/G_n.$$

E = exposure to mixture of compounds
C = calculated airborne concentration at receptor (for chemical, mg/m^3)
G = risk guideline (PEL or ERPG for chemical, mg/m^3)

Criteria for determining exceedance of risk guidelines for mixtures:

If the sum of the resulting fractions is >1 (unity), then the risk guidelines for the mixture of compounds are exceeded.

Example: if E_m is >1, exceeds guideline;
if E_m is 1 or <1, guideline has not been exceeded.

4. Chemical Interaction Considerations

Little information was found on synergism, antagonism, or potentiation of effects from combined exposure to these compounds. Only qualitative information was found, so the risk guidelines were not modified quantitatively to reflect these types of interactions.

5. Risk Guidelines Developed for Compounds

Risk guidelines were developed for each compound as requested by WHC SAE. The OSHA PEL-TWA[5] and the AIHA ERPGs[6] were used as the primary guidelines, although these were not available for all compounds. Missing ERPGs were developed by HEHF using the method described by the AIHA ERPG Committee, with minor modifications. The AIHA method was modified by:

1) Using secondary references rather than retrieving all original publications (some original references were retrieved);

2) Performing an extensive, but not exhaustive, literature search;

3) Documenting the data directly related to development of the guidelines in an abbreviated format;

4) Benchmarking (applying the guidelines developed for one chemical to another chemical with similar properties and health effects).

Benchmarking was used wherever possible to avoid spending time and effort for little or no significant difference in the resulting values. For example, formaldehyde guidelines were used for butanal: both compounds are aldehydes, the acute effects are similar (irritation), the guidelines for formaldehyde are based on irritation, and butanal is less irritating. Benchmarking is also very useful when the available information about a particular chemical is qualitative, rather than quantitative; for example, there was insufficient quantitative data to develop ERPGs for butanal, but the qualitative data on butanal's strength as an irritant indicated that using the formaldehyde guidelines was both reasonable and conservative.

When no PEL or TLV existed, surrogate values were determined by analogy with other compounds or by using the OSHA limits of either 15 mg/m^3 for low hazard particulates not otherwise classified (PNOC) or 10 mg/m^3 for more hazardous particulates not otherwise classified (PNOC).

6. Limiting Analytes Determined for Compounds

Tank waste analysis data was reported by analyte, and the probable compounds formed in the alkaline environment inside the tanks were determined by consulting chemists based on the analytes present. These compounds are listed by analyte in Attachment 3. Development of risk guidelines was organized by first listing each compound under the analyte representing the hazardous component of the compound (for example, sodium arsenite was listed under the analyte "arsenic"). Analytes limiting the amount of a compound that could be present were indicated on the list; these were determined by the chemical moiety that was reported in lower concentration (i.e., sodium antimonate is limited by the amount of antimony, not sodium). Some excess conservatism in estimating amounts present occurred when the same analyte is contained in compounds in different health effects groups. In these cases, the analyte is "counted" more than once: first in one group, then in the other.

7. Guidelines Developed for Toxics

Guidelines were developed for toxics based on the weight of the analyte (the toxic component) in the most hazardous compound listed under the analyte. First the most hazardous compound was determined and ERPGs were developed for it. Then the limits for the analyte were derived by multiplying the compound limits by the per cent by weight of the analyte in the compound. This is conservative for the other, less toxic compounds containing the same analyte. (The same calculations were performed for each of the less toxic compounds to verify that the analyte limits derived from the most hazardous compound were actually the lowest.)

If the original PELs and ERPGs were analyte-based, no changes or adjustments were necessary.

8. Guidelines Developed for Corrosives and Irritants

Sodium hydroxide limits were chosen to represent all compounds in this group for several reasons:

1) it is the most corrosive compound in the group;
2) it is present in the greatest quantity in the tanks; and
3) draft ERPGs have already been developed by PNL.

(NaOH also has the lowest molecular weight of any of the compounds in this group.) Guidelines for this group of compounds were normalized to those for sodium hydroxide (2, 40, and 100 mg/m^3) by first calculating the ratio of the molecular weight of the compound to that of sodium hydroxide, then multiplying the sodium hydroxide guideline values by that ratio. For example, the ERPG-1 for barium is based on barium hydroxide after normalizing to sodium hydroxide as follows:

$$171_{\text{mw } Ba(OH)_2} \;/\; 40_{\text{mw NaOH}} = 4.3 \;;\; 2.0\ mg/m^3{}_{\text{ERPG-1 for NaOH}} \times 4.3 = 8.6.$$

$$8.6\ mg/m^3{}_{\text{ERPG-1 for } Ba(OH)_2} \times .80_{\text{\% of Ba in } Ba(OH)_2} = 6.8\ mg\ Ba/m^3.$$

The guidelines for the other barium compounds, barium carbonate and barium nitrate, were calculated in the same way; the barium hydroxide limits were lowest, so they were used for all barium compounds.

This approach was also used to develop PELs for all corrosive or irritant compounds, except where the normalized value exceeded the existing PEL for the compound; in this case, the unadjusted PEL for the compound was retained.

Although normalizing by molecular weight resulted in some very high ERPG-3 levels, these are not significant in the safety analysis, since the compounds represented are only a small fraction of the total weight of the corrosives. In addition, they will be limited as total particulate mass (see section on total particulate below). Limiting the heavier compounds to the sodium hydroxide values without normalizing by weight would result in less hazardous compounds having much lower guidelines than the most hazardous, an overly conservative approach.

9. Guidelines Developed for Total Particulate

The guidelines used for total particulate are: PEL 10 mg/m^3; ERPG-1 30 mg/m^3; ERPG-2 50 mg/m^3; and ERPG-3 500 mg/m^3.[5] Note that these values do not necessarily correspond to the health effects defined by the ERPG categories; they are surrogate values used because little data is available on which to base ERPGs for particulates not otherwise classified (PNOCs).

The guidelines are applied to the combined mass of particles in the plume, including all three groups. Guidelines for individual compounds are not superceded by the guidelines for total particulates. However, it is unlikely that toxic concentrations in excess of the total particulate ERPG-3 of 500 mg/m^3 could be achieved. This is because 500 mg/m^3 is considered to be the maximum concentration of inhalable particles (10 μm and under) that can be sustained in a plume.

When guidelines for toxics and irritants exceed the highest particulate limit, their toxicity is low enough that a fatal dose is highly unlikely to be inhaled from the plume. However, guidelines were developed for these chemicals because doses causing moderate to severe health effects could be inhaled.

Guidelines for total particulates are based on the mass of particulate in inhaled air; even "inert" particulates may cause immediate respiratory effects such as physical irritation or blockage of air passages when inhaled. If the exposure is high enough, delayed effects such as bronchitis or pulmonary edema may occur, as well as impairment of lung clearance mechanisms and gas exchange. The compounds designated as contributors to total particulate mass only, i.e., not toxic or chemically irritant, are called "Total Particulates Only" in this document. Although this group does not strictly fit the OSHA definition of PNOCs (for example, some have PELs based on toxicity due to chronic exposure, such as lead and silver), it is highly unlikely that a toxic dose could be inhaled in one hour.

10. General Assumptions Used

The following assumptions and methods were used by HEHF in evaluating chemicals for the ASA:

* The upper concentration limit for airborne particulate is 500 mg/m^3.
* All airborne particulate is considered to be inhalable (i.e, ranging from 10 μm to 0.1 μm in diameter).
* All inhaled particulate is considered to be retained (not exhaled).
* All inhaled particulate is considered to be absorbed, thus contributing to dose.
* All exposures are calculated to occur over a one-hour time period, to be consistent with the AIHA ERPGs.
* All doses are considered on a once-in-a-lifetime basis, thus effects that would be expected to occur only as a result of chronic exposure are not considered.

* Primary consideration is given to the most severe and/or the most likely effects on an acute basis (i.e., if a substance is both toxic and irritant, but a toxic dose is not likely to be inhaled, irritation is considered the primary effect).

* The categories of effects defined in the criteria for the ERPG levels are used to determine risk guidelines.

* The hierarchy of data listed in the AIHA ERPG[6] and NRC COT[9] documents is used (human inhalation, human ingestion, animal inhalation, animal ingestion, etc.).

* Extrapolation of data -- oral to inhalation and animal to human is done according to approaches suggested by the NRC COT.

The above assumptions are conservative for the following reasons:

* The rationale for applying an upper limit to total particulate concentration comes from the physical behavior of particles in air, i.e., there is a finite amount of particulate matter that will stay airborne. This depends on the solubility, particle size distribution (aerodynamic diameter), density, and concentration in the plume, among others. Generally, particles larger than 10 μm do not stay airborne very long, fewer of those that do stay airborne are inhaled, and fewer yet penetrate past the nasal passages, from which they are quickly cleared. The smallest particles agglomerate or coagulate (by the square of the concentration) into larger ones, which drop out of the plume sooner and do not penetrate as deeply if inhaled. Thus in scenarios where the particle size distribution of the release fraction is assumed to be log-normal (or bi-modal), the actual plume concentration available for inhalation by the 100 m receptor is overestimated.

* All inhaled particulate is unlikely to be retained; retention is affected by a number of factors, including particle size, solubility, concentration in air, et al. The GENII model for radioactive particles assumes that all particles are 1 μm in diameter, and only 60 per cent are retained in the respiratory system.

* The predominant particulates in the waste are corrosive or strongly irritating; the normal bronchoconstriction response to respiratory irritants reduces the total amount of airborne particles that are inhaled by reducing the total volume of air inhaled. In addition, the excellent warning properties of this particulate would cause people to try escape the exposure immediately. Furthermore, as the concentration increases from 10 mg/m^3 up to (and possibly above) 100 mg/m^3 the fraction of inhaled particulate that is retained <u>decreases</u>, while the converse

is true for lower concentrations; increasing fractions are retained at concentrations of 10 mg/m^3 and less.

* Since it is known that all inhaled particles are not retained initially, the total dose from absorption is also overestimated; furthermore, even retained particulate is partially cleared from the lungs by several mechanisms. The irritant nature of the particulate causes coughing and sneezing, two of the mechanisms that increase the rate of particulate clearance. Also, excretion of unmetabolized chemicals by other routes (e.g., urine, feces, sweat) would further decrease the amount of chemical present in the body, reducing the toxic dose.

* Many exposure durations described in the release scenarios are less than the one hour that the ERPGs are based on and the eight hours the PEL-TWA is based on. Some are only a few minutes; however, some release durations are for many hours. Using the one-hour exposure duration is conservative in the first case, and reasonable in the second case, since the chemical mixture has good warning properties (irritation and odor, and possibly visibility). A one-hour release of sufficient quantity to produce a plume at 100 meters or more would be noticed, and it would prompt the removal of people from exposure or the donning of personal protective equipment if they must be exposed while performing emergency duties .

* Unprotected exposures are limited to a maximum of one hour at ERPG concentrations (even for continuous releases) by emergency response actions such as evacuation or donning personal protective equipment.

* Considering all exposures as a once-in-a-lifetime event is appropriate, because the scenarios being evaluated are for accidents. Even though the highest potential frequency evaluation is once per year, these are accidents with a low probability of occurrence. This pattern of exposure is not considered chronic, so effects that are only associated with chronic (repeated) exposures were not considered.

  It is beyond the state-of-the-art of toxicology in most cases to predict the chronic effects that might result from a single acute exposure to chemicals. (It is difficult to predict the dose level required to produce the effect even when the exposure is chronic.) Qualitative data on mutagens, teratogens, and carcinogens serves as a warning to avoid unnecessary exposure, but does not indicate the threshold for effects from acute or chronic exposures.

  Accident scenarios require risk guidelines that are predictive of the anticipated health effects, just as the workplace limits for risk of illness from chronic exposure do. The PELs are based on chronic (repeated) exposure, even when they are intended to prevent an acute effect such as irritation. Using the PELs is

conservative for single, acute exposures, except in some cases where PELs are set higher because workers who are chronically exposed to the chemical tend to develop tolerance for the effects. This is especially true of the irritants; the general public (as well as previously unexposed workers) will experience more irritation than workers who have been repeatedly exposed. PELs for sensitizers are lower than the ERPG-1 to prevent sensitization of chronically exposed workers, who, if they do become sensitized, must be removed from exposure. Sensitization is possible from a single exposure, but is not likely with the tank waste chemicals, or at the low air concentrations anticipated.

Differences in the PELs and the ERPG-1 values are due to the factors above. When the 8-hour PEL is higher than the 1-hour ERPG-1 value, the lower ERPG-1 is used in its place. In other instances, the PEL is orders of magnitude lower than the ERPG-1 because it was set at the limit of sampling and analytical detection (due to the uncertainty about concentrations causing such chronic effects as carcinogenicity or sensitization). These very low PELs are overly conservative for safety analysis because the probability of illness from a single exposure is very low.

* Placing all compounds into one of three groups helps to reduce the need to "count" analytes repeatedly, and avoids excessive overestimations of the combined exposure effects. Also, for compounds that are both toxic and irritant or corrosive, the exposure limits that prevent irritation are lower than the toxicity limits.

Attachments:

1. Appendix A Working Table
2. Potential Compounds from Appendix A Grouped by Health Effects
3. Appendix A Compounds and Limiting Analytes
4. Guidelines for Solids, Liquids, and Vapors (Toxics and Corrosives and Irritants)
5. References Used in Toxicological Evaluation

1. WHC-SD-WM-SARR-011, Rev 0, Toxic Chemical Considerations for Tank Farm Releases, J. S. Davis, 1994.

2. WHC-SD-WM-SARR-011, Rev 0.

3. See Attachment 1.

4. See Attachment 2.

5. OSHA, 1989. 29 CFR Part 1910.1000; Air Contaminants -- Permissible Exposure Limits, U.S. Dept. of Labor, Occupational Health and Safety Administration.

PEL-TWA: Permissible Exposure Limit, Time-Weighted Average

6. AIHA 1989, ERPGs: Concepts and Procedures for the Development of Emergency Response Planning Guidelines (ERPGs), AIHA ERPG Committee, American Industrial Hygiene Association, AKRON, OH.

AIHA 1991, "Emergency Response Planning Guidelines", AIHA Emergency Response Planning Guideline Committee, American Industrial Hygiene Association, Akron, OH. [New data sets issued as they are developed.]

7. The PEL for Particulates Not Otherwise Characterized (PNOCs) limits exposure to chemicals for which no PELs have been developed. Although their toxicity is low, OSHA and NIOSH state that the PEL may not be protective for all PNOCs.

29 CFR Part 1910; Air Contaminants, Preamble to Final Rule (Federal Register / vol. 54, No. 12 / Thursday, January 19, 1989 / Rules and Regulations, pp 2332-2981).

8. ERPG-1 and ERPG-2 are multiples of the PEL, according to the methodology used in the WHC M & O Committee Document. ERPG-3 is based on the highest concentration that can be sustained in a plume, per Doug Craig (teleconference on January 3, 1995).

9. NRC COT, 1986, Criteria and Methods for Preparing Emergency Exposure Guidance Level (EEGL), Short-Term Public Emergency Guidance Level (SPEGL), and Continuous Exposure Guidance Level (CEGL) Documents, prepared by the Committee on Toxicology, Board on environmental Studies and Toxicology, Commission on Life Sciences, National Research Council, National Academy Press, Washington, DC.

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ATTACHMENT 1

APPENDIX A WORKING TABLE

This attachment can be found in Appendix A.1.

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ATTACHMENT 2

POTENTIAL COMPOUNDS FROM APPENDIX A
Grouped by Health Effects

All compounds and formulas from Appendix A, WHC-SD-WM-SARR-011, Rev. 0, "WORKING TABLE USED TO DETERMINE: (A) CHEMICAL COMPOUNDS IN TANK SOLIDS AND LIQUIDS, AND (B) WHICH COMPOUNDS REQUIRE RELEASE CONSEQUENCE ASSESSMENTS" are listed below in three groups by health effects. Each compound appears on only one list, based on the predicted health effects from acute inhalation for up to one hour. The three lists are: 1) "TOTAL PARTICULATE ONLY: Not toxic by acute inhalation; not corrosive or chemically irritating"; 2) "CORROSIVES AND IRRITANTS"; and 3) "TOXICS".

The compounds are listed alphabetically by name within each health effects group. This is the working list for toxicological review and guideline development for tank solids and liquids. In some cases, missing formulas were not readily available for compounds that were named in App. A; in other cases, formulas were provided without names. Because the compounds are formed in alkaline environments, general chemical references did not always have the same formulas and names for these compounds, and the missing ones are indicated by a dotted line. Names and formulas in parentheses were added by HEHF.

"TOTAL PARTICULATE" ONLY: Not toxic by acute inhalation; not corrosive or chemically irritating

$Al_2(CO_3)_3$	Aluminum Carbonate
$Al(OH)_3$	Aluminum Hydroxide (Gibbsite)
$AM(OH)_3$	Americium Hydroxide
$AlPO_4$	Aluminum Phosphate
$Bi_2(CO_3)_3$	Bismuth Carbonate
$Bi(OH)_3$	Bismuth Hydroxide
$BiPO_4$	Bismuth Phosphate
$AlO(OH)$	Boehmite
$CaCO_3$	Calcium Carbonate
$Cu(OH)_2$	Cupric Hydroxide
----	Diatomaceous Earth
$Fe(OH)_3$	Ferric Hydroxide

FeCN	Ferrocyanide
$Fe_4^{+3}[Fe(CN)_6^{-4}]_3$	(ferric ferrocyanide)
$Fe_3^{+2}[Fe(CN)_6^{-3}]_2$	(ferrous ferricyanide)
$Fe_2(CO_3)_3$	Ferric Carbonate
-----	Iron sulfate
-----	Iron sulfide
$Pb(OH)_2$	Lead Hydroxide
$Pb(OH)_4$	-----
$MgCO_3$	Magnesium Carbonate
$Mg(OH)_2$	Magnesium Hydroxide
MnO_2	Manganese Dioxide
-----	Metal Fluorides
----	Metal Sulfates
-----	Metal Sulfides
$Mo_2O_3{}^*H_2O$	Molybdate Monohydrate
NpO_2OH	Neptunium Hydroxide
$Ni(OH)_4^{-2}$	-----
$Ni(OH)_3$	Nickelic Hydroxide
$Ni(OH)_2$	Nickelous Hydroxide
-----	Nitrosyl Compounds
$Pd(OH)_2$	Palladium Hydroxide
$Pd(OH)_4$	Palladium Hydroxide
$Pu(OH)_3$	Plutonium Hydroxide
$Pu^{+4}F_4$	Plutonium Fluoride
-----	Polyphosphates
KNO_3	Potassium Nitrate

Rh_2O_3	Rhodium Trioxide
Ru_2O_4	Ruthenium Tetraoxide
Ru_2O_3	Ruthenium Trioxide
SiO_2	Silica
AgCl	Silver Chloride
Ag_2O	Silver Oxide
$NaCH_3COO-$	Sodium Acetate
$NaAlSiO_4$	(sodium aluminum silicate)
$NaAlOH_4$	Sodium Aluminate
$NaHCO_3$	Sodium Bicarbonate
Na_2HPO_4	(sodium biphosphate)
Na_3BO_3	Sodium Borate
NaCl	Sodium Chloride
$Na_3C_6H_5O_7$	Sodium Citrate
$Na_2Fe(CN)_6$	(sodium ferricyanide)
$Na_7F(PO_4)^2$	Sodium Fluoride Diphosphate
-----	(sodium glycolate)
Na2NiFe(CN)6	(sodium nickel ferrocyanide)
$NaMoO_4$	Sodium Molybdate
$NaReO_4$	Sodium Rhenate
Na_2RuO_4	Sodium Ruthenate
Na_2SnO_3	Sodium Stannate
$NaSO_4$	Sodium Sulfate
Na_2SO_4	Sodium (bisulfate)
Na_2SO_3	Sodium Sulfite
Na_3TaO_4	Sodium Tantalate

Na_2TiO_3	Sodium Titanite/Titanate
Na_2WO_4	Sodium Tungstate
NaZrO	Sodium Zirconate
$Sr(CO)_3$	Strontium Carbonates
$Sr(SO)_4$	Strontium Sulfates
$Ta_2O_5{}^*H_2O$	Tantalum Oxide
$ThO_2{}^*H_2O$	Thorium Oxide
$Th(OH)_4$	Thorium Hydroxide
$Sn(OH)_2$	Tin Hydroxide
$SnO_2{}^*H_2O$	Tin Oxide
TiO_2	Titanium Dioxide
$Ti(OH)_4$	Titanium Hydroxide
$Zn(OH)_2$	Zinc Hydroxide
$ZrF_6/ZrOF_2$	Zirconium Fluoride
$Zr(OH)_4$	Zirconium Hydroxide
$ZrO(NO_3)_2$	(zirconyl nitrate)
$ZrO_2{}^*H_2O$	Zirconium Dioxide Monohydrate
Na_4EDTA	(sodium salt of EDTA)
Na_3HEDTA	(sodium acid EDTA)
$NaAlSiO_2$	-----

CORROSIVES AND IRRITANTS

NH_4NO_3	Ammonium Nitrate
$Ba(OH)_2$	Barium Hydroxide
$BaCO_3$	Barium Carbonate
$Ba(NO_3)_2$	Barium Nitrate
$Ca(OH)_2$	Calcium Hydroxide
$Cr(NO_3)_3$	(chromium nitrate)
$Cr(OH)_3$	(chromium hydroxide)
$La(OH)_3$	Lanthanum Hydroxide
$LaPO_4$	Lathanum Phosphate
$LiNO_3$	Lithium Nitrate
$NaAlO_2$	Sodium Aluminate
$NaNO_3$	Sodium Nitrate
$NaNO_2$	Sodium Nitrite
Na_2CO_3	Sodium Carbonate
Na_2CrO_4	Sodium Chromate
NaHCOO	Sodium Formate
NaOH	Sodium Hydroxide
Na_3PO_4	Sodium Phosphate Tribasic
Na_4SiO_4	Sodium Silicate
Na_4SiO_3	(sodium silicate)
Na_2S	Sodium Sulfide
$NaNO_3$	Sodium Nitrite

TOXICS

CH_3COCH_3	Acetone (liquid)
Sb_2O_5	Antimony Pentoxide
$Be(OH)_2$	Beryllium Hydroxide
$CH_3CH_2CH_2CH_2OH$	Butyl Alcohol
$Cd(OH)_2$	Cadmium Hydroxide
CaC_2O_4	Calcium Oxalate
$Ce(OH)_3$	Cerous Hydroxide
$Co(OH)_2$	Cobaltic Hydroxide
$CO_2O_3 \cdot H_2O$	Cobaltic Trioxide Monohydrate
$(C_8H_{19}PO_4)$	(dibutylphosphate), DBP
$Dy(OH)_3$	Dysprosium Hydroxide
LaF_3	Lanthanum Fluoride
$Hg(OH)_2$	Mercury Oxide
HgOH	(mercury hydroxide)
-----	(monobutylphosphate), MBP
NPH	Normal Paraffin Hydrocarbons (do- and tri-decane)
NdF	Neodymium Fluoride
$Nd(OH)_3$	Neodymium Hydroxide
$NaSb(OH)_4$	Sodium Antimonate
$NaBeO_2$	(sodium beryllium oxide)
NaCN	Sodium Cyanide
NaF	Sodium Fluoride
NaOH	Sodium Hydroxide
$NaAsO_3$	Sodium Metaarsenate
Na_3AsO_4	Sodium Orthoarsenate

$Na_2C_2O_4$	Sodium Oxalate
Na_2SeO_4	Sodium Selenate
Na_2TeO_3	Sodium Tellurite
$NaTl(OH)_4$	Sodium Thallate
$NaVO_3$	-----
$Na_2[VO_3(OH)]$	Sodium Vanadate
Na_4VO_4	Sodium Vanadite
SrC_2O_4	Strontium Oxalate
TeO_2*H_2O	Tellurium Dioxide
$Tl(OH)_3$	Thallium Hydroxide
$(C_{12}H_{27}PO_4)$	Tributyl Phosphate (TBP)
(U)	Uranium, insoluble compounds only

Zirconate (limiting analyte)
- Sodium zirconate
- Sodium zirconate (Na_2ZrO_3)

Zirconium (limiting analyte)
- Zirconium dioxide monohydrate
- Zirconium fluoride
- Zirconium hydroxide

Zirconyl (limiting analyte)
- Zirconyl nitrate ($ZrO(NO_3)_2$)

ATTACHMENT 3

Appendix A Compounds By Analyte

Analytes for solids and liquids in Appendix A, WHC-SD-WM-SARR-011, Rev. 0, are listed alphabetically below and the compounds are in alphabetical order under the applicable analyte. Compounds are designated for consideration in the safety analysis as toxic (t), corrosive or irritant (c), and as contributors to total particulate only (o) (i.e., not of concern for toxic, corrosive, or irritant effects for a one-hour exposure duration). Consideration is given to acute health effects from acute inhalation for up to one hour; chronic effects such as carcinogenesis and sensitization have not been considered in this review.

For some radionuclides, such as Plutonium, Americium, and Neptunium, concentrations that cause acute radiotoxicity are lower than concentrations that cause acute chemical toxicity, so the radiological aspects are limiting. These compounds have been designated (r) because they are not covered in the toxicological guidelines.

"Limiting analytes" indicates the chemical moieties which limit the amount of the associated compound(s) calculated to be present in the tank waste.

Acetate (limiting analyte)
- o Sodium acetate

Acetone (liquid) (limiting analyte)
- t Acetone

Aluminates (see specific compounds)

Aluminum (aluminate is limiting analyte)
- o Aluminum carbonate
- o Aluminum hydroxide
- o Aluminum phosphate
- o Bentonite
- o Boehmite ($AlO(OH)$)
- c Sodium aluminate ($NaAlO_2$)
- o Sodium aluminate ($NaAlOH_2$)
- c Sodium aluminum silicate ($NaAlSiO_4$)

Americium (limiting analyte) (Rad is limiting)
- r Americium hydroxide

Ammonia (nitrate is limiting analyte)
c Ammonium nitrate

Antimony (as Sb) (limiting analyte)
t Antimony pentoxide
t Sodium antimonate

Arsenic (as As) (limiting analyte)
t Sodium metaarsenate
t Sodium orthoarsenate
t Sodium arsenite ($NaAsO_2$)

Barium (limiting analyte)

c Barium hydroxide
c Barium carbonate
c Barium nitrate
t Barium sulfate

Beryllium (as Be) (limiting analyte)
t Beryllium hydroxide
t Sodium beryllium oxide ($NaBeO_2$)

Bismuth (limiting analyte) (total particulate only)
o Bismuth carbonate
o Bismuth hydroxide
o Bismuth phosphate

Boron (limiting analyte)
o Sodium borate (Na_3BO_3)
c Sodium tetraborate, anhydrous ($Na_2B_4O_7$)

Butanol (liquid)
t Butanol

Cadmium (limiting analyte)
t Cadmium hydroxide

Calcium (either Ca or oxalate, whichever is lower)
c Calcium hydroxide
t Calcium oxalate
o Calcium carbonate
c CaOH-silica-H_2O
o Calcium sulfate
o Cement and concrete

Carbonates (see specific compounds)

Cerium (limiting analyte)
t Cerous hydroxide

Chlorides (see specific compounds)

Chromates (limiting analyte)
c Sodium chromate

Chromium (limiting analyte)
c Chromium nitrate
c Chromium hydroxide

Citrate (see compound [sodium citrate])

Cobalt (limiting analyte)
t Cobaltic hydroxide
t Cobaltic trioxice H2O
t Cobalt sulfide

Copper (limiting analyte)
o Cupric hydroxide

Cyanide (Hydrogen cyanide not present) (limiting analyte)
t Sodium cyanide
o Ferrocyanide
o Ferric ferrocyanide
o Ferrous ferrocyanide
t Sodium ferricyanide ($Na_2Fe(CN)_6$)
o Sodium nickel ferrocyanide ($Na_2NiFe(CN)_6$)

Dibutylphosphate (see organophosphates)

Dysprosium (limiting analyte)
c Dysprosium hydroxide

EDTA (Ethylenediaminetetraacetic acid) (limiting analyte)
o EDTA
o Sodium acid EDTA (Na_3HEDTA)
o Sodium salt of EDTA (Na_4EDTA)

Ferrocyanides (see cyanide)

Formic acid (formate is limiting analyte: subtract from TOC)
c Sodium formate

Fluorides (see specific compounds)

Glycolates (limiting analyte)
o Sodium glycolate

Hydrogen (evaluated with gases and vapors)
3

Hydrogen fluoride (not present; see sodium fluoride)

Hydroxides (see specific compounds)

Iron (limiting analyte)
- o Ferric carbonate
- o Ferric hydroxide
- o Iron sulfate
- o Iron sulfide

Lanthanum (limiting analyte: La or F, whichever is lower)
- t Lanthanum fluoride
- c Lanthanum hydroxide
- o Lanthanum phosphate

Lead (as Pb and inorganic cmpds) (limiting analyte)
- o Lead hydroxide $(Pb(OH)_2$
- o $(Pb(OH)_4$

Lithium (limiting analyte)
- c Lithium nitrate

Magnesium (limiting analyte)
- o Magnesium carbonate
- o Magnesium hydroxide

Manganese (as Mn) (limiting analyte)
- o Manganese dioxide

Mercury (as Hg) (limiting analyte)
- t Mercury oxide
- t Mercury hydroxide (HgOH)

Metal fluorides (see specific compounds)

Metal sulfates (see specific compounds)

Metal sulfides (see specific compounds)

Minerals (silicates are limiting analytes)
- o Cancrinite
- o Zeolite
- o Sodium aluminosilicate

Molybdenum (as Mo) (limiting analyte)
- o Molybdate monohydrate
- o Sodium molybdate

Monobutylphosphate (see organophosphates)

Neodymium (as Nd) (limiting analyte)
t Neodymium fluoride
t Neodymium hydroxide

Neptunium (as Np) (limiting analyte) (Rad is limiting)
r Neptunium hydroxide

Nickel (as Ni) (limiting analyte)
o Nickelic hydroxide
o Nickelous hydroxide
o $(Ni(OH)_{1-2}$

Nitrates and Nitrites (see specific compounds)

Nitrosyl
o Nitrosyl compounds (unspecified)

NPH (Normal paraffin hydrocarbons) (limiting analyte)
t Dodecane
t Tridecane

Organophosphates (limiting analyte TOC; consider all OPs as TBP)
t Dibutylphosphate
t Monobutylphosphate
t Tributylphosphate
t Tributylphosphate, sodium salt (stable)

Oxalates (see specific compounds)

Palladium (limiting analyte)
o Palladium hydroxide ($Pd(OH)_2$ or $Pd(OH)_4$)

Particulates, total (see total particulates)

Phosphates (see organophosphates and other specific compounds)

Plutonium (limiting analyte) (Rad is limiting for all Pu compounds)
r Plutonium hydroxide
r Plutonium fluoride

Polyphosphates
o Polyphosphates (unspecified)

Potassium (as K) (limiting analyte)
o Potassium nitrate

Rhenium (as Re) (limiting analyte)
o Sodium rhenate

Rhodium (as Rh) (limiting analyte)
o Rhodium trioxide

Ruthenium (as Ru) (limiting analyte) (Rad is limiting for all Ru compounds)
r Ruthenium tetraoxide
r Ruthenium trioxide
r Sodium ruthenate

Selenates (see specific compounds and selenium)

Selenium (as Se) (limiting analyte)
t Sodium selenate

Silicates (see specific compounds and minerals)

Silicon (limiting analyte)
o Diatomaceous earth
o Silica (quartz, minerals)

Silver (as Ag) (limiting analyte)
o Silver chloride
o Silver oxide

Sodium (sodium is not the limiting analyte; use other analytes) (see also sodium compounds under other analytes)
o Sodium bicarbonate
o Sodium biphosphate (Na_2HPO_4)
o Sodium bisulfate (NA_2SO_4)
c Sodium carbonate
o Sodium chloride
c Sodium citrate
o Sodium fluoride diphosphate
c Sodium hydroxide
c Sodium nitrate
c Sodium nitrite
c Sodium oxalate
c Sodium phosphate tribasic
c Sodium silicate (liquid) (Na_4SiO_3 or Na_4SiO_4)
o Sodium sulfate
c Sodium sulfide
o Sodium sulfite
o Sodium thiosulfate

Strontium (limiting analyte) (consider all as oxalate)
o Strontium carbonate
t Strontium oxalate
o Strontium sulfate

Sulfates (see specific compounds)

Sulfites (see specific compounds)

Sulfur (limiting analyte)
c Sodium sulfide
o Iron sulfide

Tantalum (limiting analyte)
o Sodium tantalate
o Tantalum oxide

Tellurium (limiting analyte)
t Sodium tellurite
t Tellurium dioxide

Thallium (limiting analyte)
t Sodium thallate
t Thallium hydroxide

Thorium (limiting analyte)
o Thorium hydroxide
o Thorium oxide

Tin (limiting analyte)
o Sodium stannate
o Tin hydroxide
o Tin oxide

Titanium
o Titanium dioxide
o Titanium hydroxide
o Sodium titanite/titanate

Total particulates (total release mass is limiting)
o Total particulate

Tributylphosphate (see organophosphates)

Tungstates (see tungsten)

Tungsten (limiting analyte is tungstate)
o Sodium tungstate

Uranium (limiting analyte) (consider all U as soluble)
t Insoluble compounds

Vanadium
t $NaVO_3$
t Sodium vanadate ($Na_3[VO_3(OH)]$)
t Sodium vanadite

Zinc (limiting analyte)
o Zinc hydroxide

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ATTACHMENT 4

TANK VAPOR CHEMICALS

Grouped by Health Effects

Tank vapor chemicals from WHC-SD-WM-SAR-011, Rev. 0, are grouped under Central Nervous System Depressants, Systemic Poisons, or Corrosives and Irritants on the basis of their most significant acute effects from acute inhalation exposure (for up to one hour).

TOXICS

CNS Depressants

Benzene
Butanol
Dodecane
Tridecane
n-Hexane
2-Hexanone (Methyl-n-butyl ketone)

Systemic Poisons

Acetonitrile
Propane nitrile (Propionitrile)

IRRITANTS and CORROSIVES

Acetone
Ammonia
1,3-Butadiene
Butanal
Methylene chloride
Tributylphosphate

ATTACHMENT 5

Risk Guidelines For Tank Waste Chemicals

The following risk guidelines as shown in Tables F-1, F-2, and F-3 are recommended by HEHF for the Tank Farms Accelerated Safety Analysis. For additional information see "Toxicological Evaluation of Tank Waste Chemicals" (Dentler 1995). Values represent compound limits stated in terms of the weight of the analyte in the compound.

TABLE F-1. RISK GUIDELINES FOR TANK SOLIDS AND LIQUIDS (mg/m3) (TOXICS)

ANALYTE & Compounds Covered	PEL-TWA[a] mg/m^3	ERPG-1[a] mg/m^3	ERPG-2[a] mg/m^3	ERPG-3[a] mg/m^3
ANTIMONY (as Sb)[1]	0.5	2	40	70
Antimony pentoxide	0.83	3.3	67	117
Sodium antimonate	0.88	3.5	70	123
ARSENIC (as As)[2]	0.01	0.1	7	40
Sodium metaarsenate	0.02	0.20	14	78
Sodium orthoarsenate	0.03	0.28	19	111
Sodium arsenite	0.02	0.17	12	69
BERYLLIUM (as Be)[3]	0.002	0.006	0.025	0.1
Beryllium hydroxide	0.01	0.03	0.12	0.48
Sodium beryllium oxide	0.014	0.04	0.18	0.71
CADMIUM (as Cd)[4]	0.005	0.2	1	10
Cadmium hydroxide	0.007	0.26	1.3	13
CERIUM (as Ce)[5]	2	70	500	700
Cerous hydroxide	2.8	99	704	986
COBALT (as Co)[6]	0.05	0.05	0.2	8
Cobaltic hydroxide	0.079	0.077	0.32	13
Cobaltic trioxide · H_2O	0.078	0.078	0.31	13
Cobalt sulfide[7]	0.077	0.077	0.31	12
CYANIDE (as CN^{-1}),[8]	5	5	41	200
Sodium cyanide	9.4	9.4	77	377
Sodium ferricyanide ($Na_2Fe(CN)_6$ or $Na_3Fe(CN)_6$)[9]	8.3	8.3	68	333

ANALYTE & Compounds Covered	PEL-TWA[a] mg/m^3	ERPG-1[a] mg/m^3	ERPG-2[a] mg/m^3	ERPG-3[a] mg/m^3
MERCURY (as Hg)[9]	0.05	0.075	0.10	14
Mercury oxide ($Hg(OH)_2$)	0.058	0.087	0.12	16
Mercury hydroxide (HgOH)	0.054	0.082	0.11	15
NEODYMIUM (as Nd)[10]	3.5[11]	72	504	720
Neodymium fluoride	6.3[13]	120	840	1200
Neodymium hydroxide	10[12]	96	673	962
OXALATE (as C_2O_4)[13]	1	4	20	40
Calcium oxalate	1.4	5.8	29	58
Sodium oxalate	1.5	6.1	30	61
Strontium oxalate	2	8	40	80
TOC (TOTAL ORGANIC CARBON)[14]	2.5	3	15	50
Acetone	1800	1200	8000	20000
Butanol[15]	75	75	750	7500
Formic acid (as formate):[16]	8.6	19	28	56
Sodium formate	13	29	43	86
NPHs (normal paraffin hydrocarbons):[17]	100	37	1450	7330
Dodecane (n-dodecane)	100	37	1450	7330
Tridecane (n-tridecane)	100	37	1450	7330
Organophosphates (as TBP):[18]	2.5	3	15	50
Dibutylphosphate	3.2	3.8	19	64
Monobutyl phosphate	4.3	5.2	26	87
Tributyl phosphate	2.5	3	15	50
Tributyl phosphate, stable sodium salt	2.5	3	15	50
SELENIUM (as Se)[19]	0.2	0.2	0.4	2
Sodium selenate	0.48	0.48	0.95	4.8
TELLURIUM (as Te)[20]	0.1	0.13	0.3	1.4
Sodium tellurite	0.17	0.56	1.1	5.6
Sodium tellurate	0.19	0.60	1.2	6.2
Tellurium dioxide	0.14	0.51	1.0	5.3
THALLIUM (as Tl)[21]	0.1	0.3	2	20

ANALYTE & Compounds Covered	PEL-TWA[a] mg/m^3	ERPG-1[a] mg/m^3	ERPG-2[a] mg/m^3	ERPG-3[a] mg/m^3
Sodium thallate	0.14	0.43	2.9	29
Thallium hydroxide	0.13	0.38	2.5	25
URANIUM (as U)[22]	0.2	1	10	20
Insoluble compounds (as U)	0.25	1	10	20
VANADIUM (as V)[23]	0.03	1.2	11	40
Sodium vanadate ($NaVO_2$)	0.08	3.2	29	107
Sodium vanadate ($Na_3[VO_3(OH)]$)	0.06	2.3	22	78
Sodium vanadite	0.06	2.4	22	80

[a] Or surrogate. See endnotes for explanation of surrogates.

TABLE F-2. RISK GUIDELINES FOR TANK SOLIDS AND LIQUIDS (mg/m3) (CORROSIVES AND IRRITANTS)

ANALYTE & Compounds Covered	PEL-TWA[a]	ERPG-1[a]	ERPG-2[a]	ERPG-3[a]
AMMONIA (as NH_3)[24]	0.46	0.46	9.2	23
Ammonium nitrate	4	4	80	200
BARIUM (as Ba)[25]	0.5	6.8	138	344
Barium carbonate	0.71	10	200	500
Barium hydroxide	0.63	8.6	172	430
Barium nitrate	0.96	13	260	650
CALCIUM (as Ca)[26]	2.7	1	22	54
Calcium hydroxide	5	3.7	74	185
CaOH-silica-H_2O	10	7.6	152	380
CHROMIUM (as Cr+3)[27]	0.5	2.6	51.5	129
Chromium nitrate	2.3	12	240	600
Chromium hydroxide	1	5.2	103	258
DYSPROSIUM (as Dy)[28]	2.2	80	600	800
Dysprosium hydroxide	3.4	110	800	1100
LANTHANUM (as La)[29]	6.9	6.9	137	343

ANALYTE & Compounds Covered	PEL-TWA[a]	ERPG-1[a]	ERPG-2[a]	ERPG-3[a]
Lanthanum hydroxide	9.5	9.5	190	475
Lanthanum fluoride	9.8	9.8	196	490
Lanthanum phosphate	12	12	234	585
LITHIUM (as Li)[30]	0.34	0.34	6.9	17
Lithium nitrate	3.45	3.45	69	173
SODIUM (as Na)[31]	1.2	1.2	23	58
Sodium aluminate	4.1	4.1	82	205
Sodium carbonate	7	7	106	265
Sodium chromate	8	8	160	400
Sodium citrate	13	13	258	645
Sodium fluoride[32]	2.1	2.1	42	105
Sodium formate[33]	3.2	3.2	64	160
Sodium nitrate	4.3	4.3	80	210
Sodium nitrite	3.5	3.5	65	170
Sodium phosphate tribasic	8.2	8.2	164	410
Sodium silicate (liquid)	5.8	5.8	116	290
Sodium sulfide[34]	3.9	3.9	78	195
Sodium tetraborate, anhydrous	9.0	9.0	179	448
SODIUM HYDROXIDE (as NaOH)	2	2	40	100

a Or surrogate. See endnotes for explanation of surrogates.

TABLE F-3. RISK GUIDELINES FOR VAPOR SPACE CONSTITUENTS (mg/m3)

ANALYTE & Compounds Covered	PEL-TWA	ERPG-1*	ERPG-2*	ERPG-3*
TOXICS - CENTRAL NERVOUS SYSTEM DEPRESSANTS				
Benzene	3	78	1565	3130
Butanol (n-butyl alcohol)[35]	75	75	750	7500
Dodecane (similar to kerosene)[9]	100	37	1450	7330
2-Hexanone[36] (Methyl-n-butyl-ketone)	20	50	500	5000

ANALYTE & Compounds Covered	PEL-TWA	ERPG-1*	ERPG-2*	ERPG-3*
Nitrous oxide (N_2O)[37]	90	270	18000	36000
Tridecane,[19] (similar to kerosene)	100	37	1450	7330
TOXICS - SYSTEMIC POISONS				
Acetonitrile[38]	67	3	20	60
Propane nitrile (propionitrile)[39]	14	3	20	60
CORROSIVES AND IRRITANTS				
Ammonia[40]	17	17	140	680
1,3-Butadiene[41]	22	22	110	11000
Methylene chloride[42] (Dichloromethane)	174	700	3480	17400
Tributylphosphate[43]	2.5	3	15	50

* Or surrogate. See endnotes for explanation of surrogates.

1. Guidelines for all compounds are based on Sb content originally.

2. Guidelines for all compounds are based on As content. ERPGs developed by HEHF for As.

3. Guidelines for all compounds are based on Be content. ERPGs developed for Be by PNL.

4. Guidelines developed for compound based on Cd content. ERPGs developed for Cd by HEHF.

5. PEL for cerium developed from PEL for cesium hydroxide (similar toxicity). ERPGs for cerium developed by HEHF from cerium chloride toxicity information.

6. ERPGs developed by HEHF for compounds based on Co content.

7. Guidelines for Co are protective against sulfide (H_2S) toxicity in vivo.

8. Guidelines developed for compounds based on CN content. ERPGs developed for CN compounds by HEHF.

9. Guidelines for compounds based on Hg content only; compounds limited to elemental Hg limits with no adjustment upward for molecular weight differences (conservative).

The ERPG-2 is the EPA Level of Concern (LOC): "The concentration of an extremely hazardous substance in air above which there may be serious irreversible health effects or death as a result of a single exposure

for a relatively short period of time." The ERPG-3 is the NIOSH IDLH for mercury vapor.

10. Guidelines developed from neodymium chloride toxicity data.

11. PEL developed from PEL for F; ERPG developed for compounds based on Nd content of $NdCl_2$.

12. No PEL; used 10 mg/m^3. This is well below ERPG-1 for Nd.

13. PEL for oxalic acid. Guidelines based on oxalic acid, assuming that total amount of oxalate inhaled is eventually swallowed (conservative). Values for compounds adjusted to oxalic acid by the following formula:

    ERPG for oxalic acid X mw compound / mw oxalic acid.

14. Guidelines based on PEL and ERPGs for tributylphosphate: other compounds are less toxic.

15. There is no PEL-TWA for butanol; use ERPG-1, which is half the PEL-C.

16. Formic acid guidelines (from HEHF) are used since formate becomes formic acid on contact with moist membranes; sodium ions are not a toxic or irritant concern by themselves. Sodium formate values adjusted to formic acid guidelines as follows:
    ERPG for formic acid X mw of sodium formate / mw of formic acid.

17. PEL-TWA based on NIOSH REL; ERPGs developed by HEHF. (Values not adjusted by compound weight; values are applicable to all NPHs.)

18. Values given are for TBP since there is no PEL for DBP or MBP; TBP is the heaviest of the compounds in this group, and also the most toxic, so using TBP guidelines is conservative. ERPGs developed by HEHF for TBP are conservative for DBP, MBP, and sodium salt of TBP.

19. Based on toxicity of sodium selenate.

20. Guidelines for sodium tellurite/tellurate (HEHF ERPG) developed from guidelines for sodium selenate (HEHF ERPG) because these compounds have similar toxicity.

21. ERPGs for thallium developed by HEHF.

22. All uranium in the tanks is considered insoluble; however, the ERPGs are based on soluble uranium compounds. The primary acute effect of soluble U compounds is from chemical toxicity of the kidneys, while the primary acute effect of insoluble U compounds is from radiotoxicity to the lungs. Using the ERPGs for uranium hexafluoride and uranyl nitrate (AIHA,in press) is conservative, since UF_6 is more toxic than the U compounds in the waste.

23. PEL-TWA and ERPGs developed by HEHF based on vanadium pentoxide. using the values derived from the pentoxide is conservative because the pentoxide is the most toxic compound.

24. Guidelines for ammonia derived from ammonium hydroxide, normalized to NaOH.

25. PEL is for soluble Barium compounds, as Ba; PELs for compounds derived by dividing the percentage of Ba in the compound into 0.5 mg/m^3. (This is more conservative than using the NaOH PEL of 2 mg/m^3, and also conservative because the PEL for Ba is based on preventing Ba poisoning from chronic exposure, rather than short-term.)

    ERPGs were derived for Ba compounds by normalizing to NaOH guidelines by compound weight. ERPG for Ba derived from normalized values for $Ba(OH)_2$; this is conservative because values derived in same manner for the other compounds are higher.

26. PEL for Ca based on CaOH; PELs for other compounds normalized to CaOH PEL. ERPGs for compounds normalized to NaOH guidelines by compound weight. Using CaOH values is conservative, because values for other compounds are higher.

27. ERPGs are based on compound weight, normalized to NaOH guidelines. Using chromium hydroxide to derive Cr concentration is conservative, because values for other chromium compounds are higher.

28. Guidelines developed for compound by HEHF based on cerous hydroxide.

29. There is no PEL for La; the PEL developed for LaF^3 (based on F content) is used. ERPGs were developed for lanthanum compounds based on compound weights normalized to NaOH guidelines. Analyte limits are based on the La content of lanthanum fluoride, which resulted in slightly lower values than for the other La compounds (conservative).

30. There is no PEL for lithium nitrate; lithium hydride PEL is overly conservative, so NaOH PEL was used. ERPGs are based on NaOH guidelines.

31. The PELs and ERPGs for each compound are based on sodium hydroxide guidelines, after normalization to sodium hydroxide by compound weight. The sodium analyte value is derived from sodium hydroxide. Due to the varying percentages of sodium in each compound, direct comparison of all compounds by their sodium content is not useful. Since sodium hydroxide is the most corrosive compound in the list, using its guidelines for the other compounds overestimates the health hazard.

32. Sodium fluoride is grouped with the corrosives because its toxic effects guidelines (PEL: 5.6; ERPG-1: 6.7; ERPG-2: 53; and ERPG-3: 889) are higher than the guidelines for its corrosive effects.

33. The risk guidelines for sodium hydroxide are applied to sodium formate because there was no data on the quantity of the formate analyte. The PEL for formic acid, which has similar toxicity, is 9 mg/m^3 and the ERPGs are 9, 29, and 57 mg/m^3. Using the NaOH PEL and ERPG-1 values is conservative for sodium formate, while using the ERPG-2 and ERPG-3 values is not. This is acceptable because so many of the compounds in this group have very conservative guidelines.

34. Although highly toxic as well as corrosive, exposure to sodium sulfide is unlikely, since it forms sodium carbonate and sodium thiosulfate on contact with air. Both of these compounds have low toxicity.

35. There is no PEL-TWA for butanol; PEL-C is 150 mg/m^3, which is higher than ERPG-1 of 75 mg/m^3. Using ERPG-1 for PEL is conservative. ERPGs developed by HEHF.

36. ERPGs developed by HEHF.

37. There is no PEL for nitrous oxide; TLV-TWA was used. ERPGs developed by HEHF.

38. ERPGs developed by HEHF for nitrile compounds.

39. There is no PEL for propionitrile; NIOSH REL is used. ERPGs for nitrile compounds developed by HEHF.

40. TLV for ammonia used because it is lower than the PEL. ERPGs published by AIHA.

41. TLV is much lower than PEL; using TLV is conservative. ERPGs published by AIHA.

42. TLV is much lower than PEL; using TLV is conservative. ERPGs developed by HEHF.

43. ERPGs developed by HEHF for TBP, DBP, and MBP.

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ATTACHMENT 6

BIBLIOGRAPHY

Toxicological Evaluation of Tank Waste Chemicals

The following references were consulted during this project for information concerning the potential health effects of chemicals, including chemical toxicity, physical state and properties, chemical properties such as corrosivity, odor levels, metabolism, dose-response, exposure history, and similarities to and interactions with other chemicals. This information was used to exclude compounds identified in Appendix A from consideration in the ASA, and to group the remaining compounds by major acute health effects. These references were also used to develop ERPGs for compounds for which neither AIHA ERPGs nor Draft ERPGs from the national laboratories were available.

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February 1, 1995

Mr. John C. Van Keuren
Criticality and Radiological Analysis
Westinghouse Hanford Company
450 Hills, MSIN H4-64
Richland, WA 99352

Dear Mr. Van Keuren:

REVIEW OF THE HANFORD EMERGENCY RESPONSE PLANNING GUIDELINES (HERPG)

As requested, I performed a technical review of the Hanford Emergency Response Planning Guidelines (HERPGs) that were developed by M. L. Dentler, Hanford Environmental Health Foundation. Overall, the HERPGs look acceptable based upon the limited scope of the HERPG process. If anything, they appear to be conservative. No doubt some of the values could be increased and some decreased if a more rigorous literature search and data analysis were performed.

I have provided Ms. Dentler with a list of comments to consider during the final write-up for the substance specific HERPGs that I examined. Most of these have already been resolved.

Bear in mind that this initial review was done based upon the limited amount of information contained in file notes for each substance. A more definitive review will be possible after the HERPGs are fully documented and the original toxicological literature is available for reference.

If you have any questions, please contact me on 373-4714.

Very truly yours,

M. Yurconic

Michael Yurconic
Safety and Risk Assessment Group
Health and Safety Section

MY/lam

cc: ML Dentler, HEHF
JS Davis, WHC

APPENDIX E

DETAILS OF THE TOXICOLOGICAL ANALYSES

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APPENDIX E

DETAILS OF THE TOXICOLOGICAL ANALYSES

The toxic chemical release analysis methods for comparison to risk guidelines are described in Sections 3.4. The majority of these calculations are made using a spreadsheet format. Details of these calculations are given in this appendix. Nine composites are evaluated: single shell liquids, single shell solids, double shell liquids, double shell solids, headspace gases, a flammable gas watch list tanks solids and liquids composite, an all-solids and all -liquids composite, and a 50% NaOH solution. As described in Section 3.4, the consequences of a 1 liter (0.26 gal) puff release and a 1 L/s (0.26 gal/s) continuous release are calculated for each composite, receptor frequency bin, and health effect. The concentration of each analyte at the receptor is divided by the appropriate ERPG or PEL-TWA and the results summed over the mix of analytes for each composite. These numbers are referred to as the "sum of fractions." The sum of fractions is multiplied by the release rate, or release amount to determine the acceptability of each accident scenario. Numbers less than 1 indicate that the risk acceptance guidelines are met. The calculations of the numbers used for the evaluation are shown in the attached spreadsheets. The spreadsheets are labeled E-1A through E-10F. The calculations are given in the following tables:

Table	Composite	Health effect	Frequency bin
Table E-1A	Single shell tank liquids	Toxic	10-2 to 1
Table E-1B	Single shell tank liquids	Toxic	10-4 to 10-2
Table E-1C	Single shell tank liquids	Toxic	10-6 to 10-4
Table E-1D	Single shell tank liquids	Corrosive	10-2 to 1
Table E-1E	Single shell tank liquids	Corrosive	10-4 to 10-2
Table E-1F	Single shell tank liquids	Corrosive	10-6 to 10-4
Table E-2A	Single shell tank solids	Toxic	10-2 to 1
Table E-2B	Single shell tank solids	Toxic	10-4 to 10-2
Table E-2C	Single shell tank solids	Toxic	10-6 to 10-4
Table E-2D	Single shell tank solids	Corrosive	10-2 to 1
Table E-2E	Single shell tank solids	Corrosive	10-4 to 10-2
Table E-2F	Single shell tank solids	Corrosive	10-6 to 10-4
Table E-3A	Double shell tank liquids	Toxic	10-2 to 1

Table	Composite	Health effect	Frequency bin
Table E-3B	Double shell tank liquids	Toxic	10-4 to 10-2
Table E-3C	Double shell tank liquids	Toxic	10-6 to 10-4
Table E-3D	Double shell tank liquids	Corrosive	10-2 to 1
Table E-3E	Double shell tank liquids	Corrosive	10-4 to 10-2
Table E-3F	Double shell tank liquids	Corrosive	10-6 to 10-4
Table E-4A	Double shell tank solids	Toxic	10-2 to 1
Table E-4B	Double shell tank solids	Toxic	10-4 to 10-2
Table E-4C	Double shell tank solids	Toxic	10-6 to 10-4
Table E-4D	Double shell tank solids	Corrosive	10-2 to 1
Table E-4E	Double shell tank solids	Corrosive	10-4 to 10-2
Table E-4F	Double shell tank solids	Corrosive	10-6 to 10-4
Table E-5A	Gases worst case	All	10-2 to 1
Table E-5B	Gases worst case	All	10-4 to 10-2
Table E-5C	Gases worst case	All	10-6 to 10-4
Table E-5D	Gases max sample data	All	10-2 to 1
Table E-5E	Gases max sample data	All	10-4 to 10-2
Table E-5F	Gases max sample data	All	10-6 to 10-4
Table E-6A	Flammable gas watchlist composite	Toxic	10-2 to 1
Table E-6B	Flammable gas watchlist composite	Toxic	10-4 to 10-2
Table E-6C	Flammable gas watchlist composite	Toxic	10-6 to 10-4
Table E-6D	Flammable gas watchlist composite	Corrosive	10-2 to 1
Table E-6E	Flammable gas watchlist composite	Corrosive	10-4 to 10-2
Table E-6F	Flammable gas watchlist composite	Corrosive	10-6 to 10-4
Table E-7A	50% NaOH	Corrosive	10-2 to 1
Table E-7B	50% NaOH	Corrosive	10-4 to 10-2
Table E-7C	50% NaOH	Corrosive	10-6 to 10-4
Table E-8A	All liquids	Toxic	10-2 to 1
Table E-8B	All-liquids	Toxic	10-4 to 10-2
Table E-8C	All-liquids	Toxic	10-6 to 10-4
Table E-8D	All-liquids	Corrosive	10-2 to 1
Table E-8E	All-liquids	Corrosive	10-4 to 10-2

Table	Composite	Health effect	Frequency bin
Table E-8F	All-liquids	Corrosive	10-6 to 10-4
Table E-9A	All solids	Toxic	10-2 to 1
Table E-9B	All solids	Toxic	10-4 to 10-2
Table E-9C	All solids	Toxic	10-6 to 10-4
Table E-9D	All solids	Corrosive	10-2 to 1
Table E-9E	All solids	Corrosive	10-4 to 10-2
Table E-9F	All solids	Corrosive	10-6 to 10-4
Table E-10A	C-106 solids	Toxic	10-2 to 1
Table E-10B	C-106 solids	Toxic	10-4 to 10-2
Table E-10C	C-106 solids	Toxic	10-6 to 10-4
Table E-10D	C-106 solids	Corrosive	10-2 to 1
Table E-10E	C-106 solids	Corrosive	10-4 to 10-2
Table E-10F	C-106 solids	Corrosive	10-6 to 10-4
Table E-11	All composites	Particulate	all
Table E-12	Summary	All	all

Tables E-1A through E-10F are the spread sheets used to compute the sum of fraction for each composite. A descriptions of the spreadsheet columns is given below.

A Analyte (for solid and liquid releases), or headspace gas concentration (for gas releases).

B Concentration of analyte or headspace gases as taken from Table 3-1 or 3-2.

C Onsite concentration resulting from unit steady state release (1 L/s (0.26 gal/s) for solids and liquids, and 1 m^3/s (35 ft^3/s) for gases). Calculated with the first equations in Section 3.3.1 for solids and liquids, and the first equations in Section 3.3.2 for gases. For solids and liquids, a conversion factor of 1,000 mg/g is included to change the resulting units into mg/m^3.

D Onsite concentration resulting from unit puff release (1 L for solids and liquids, and 1 m^3 for gases). Calculated with second equation in Section 3.3.1 for solids and liquids, and the second equation in Section 3.3.2 for gases. For solids and liquids, a conversion factor of 1,000 mg/g is included to change the resulting units into mg/m^3.

E Onsite chemical-specific risk guideline associated with event frequency in table heading. See Appendix D for information on how each guideline was determined.

F Onsite unit steady state release concentration as a fraction of the risk guideline (column C divided by column E).

G Onsite unit puff release concentration as a fraction of the risk guideline (column D divided by column E).

H Offsite concentration resulting from unit steady state release (1 L/s for solids and liquids, and 1 m^3/s for gases). Calculated with the first equation 1 in Section 3.3.1 for solids and liquids, and the second equation in Section 3.3.2 for gases. For solids and liquids, a conversion factor of 1,000 mg/g is included to change the resulting units into mg/m^3.

I Offsite concentration resulting from unit puff release (1 L for solids and liquids, and 1 m^3 for gases). Calculated with the second equation 2 in Section 3.3.1 for solids and liquids, and the second equation in Section 3.3.2 for gases. For solids and liquids, a conversion factor of 1,000 mg/g is included to change the resulting units into mg/m^3.

J Offsite chemical-specific risk guideline associated with event frequency in table heading. See Appendix D for information on how each guideline was determined.

K Offsite unit steady state release concentration as a fraction of the risk guideline (column H divided by column J).

L Offsite unit puff release concentration as a fraction of the risk guideline (column I divided by column J).

The "Sum of Fractions" row indicates the sum of the chemical-specific receptor concentration fractions of the chemical-specific risk guidelines.

For solids and liquids, the "Allowable Release" row indicates the release rate (for steady state releases) and release volume (for puff releases) that would just meet the risk guidelines. The allowable release is calculated by taking the reciprocal of the "Sum of Fractions".

For gases, the "Allowable Release" row indicates the volume release rate (for steady state releases) and release volume (for puff releases) that would just meet the risk guidelines. The allowable release is calculated by performing iterative calculations, which are necessary because of the non-linear nature of the equations used to calculate gas release consequences.

The particulate limits depend only on the density of the composite. DST and SST liquids are assumed have a density of 1.1 g/cm^3, DST and SST solids are assumed to have a density of 1.6 gm/cm_3, and the 50% NaOH solution density is taken to be 1.52 gm/cm^3. The particulate limit does not apply to gases. The particulate calculations for all composites are shown in Table E-11.

Table E-12 is a summary table which shows the unit liter release for each calculation. The constants are the particulate, toxic and corrosive and irritant sum of fraction values. The largest of the three values is then used for the accident scenario risk acceptance calculations. Largest values for

each receptor and frequency class are marked with an asterisk in Table E-11. An example is given below to illustrate the use of these numbers.

The results of the calculation for the frequency class of 10^{-2} to 1, maximum onsite individual, and 1 L/s SST liquids continuous release are given in the first row of Table 12A. The particulate sum of fractions is 1.3 E+03, the toxic is 7.2 E+02, and the corrosives and irritants is 9.6 E+03. The corrosive sum of fractions is the largest of the three values. The corrosive sum of fractions is therefore used for the accident risk acceptance calculations for this case. The value of 9.6 E+03 appears in Table 3-8 for SST liquids, maximum onsite individual, and a frequency class of 10^{-2} to 1. The release rate in L/s is then multiplied times this constant. A product of 1 or less indicates that risk acceptance criteria are met. Similar calculations are made for each composite for both onsite and offsite receptors, and each of the three frequency classes.

Table E-1A. Toxic Chemical Consequences — Unit Releases Single Shell Liquids 10-2 to 1 yr-1 Frequency - Toxics.

TABLE E-1A Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: Single Shell Tanks/Liquids Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-2 to 10-0 per year Release Height: Ground Level
Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)				
		Release Type: Steady State / Puff		Release Duration: > 3.6s / < 3.6s		χ/Qs: 3.4E-2 s/m3 / 9.8E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 480 s		χ/Qs: 1.8E-5 s/m3 / 4.8E-6/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk** Guide PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	3.0E-03	1.2E-01	3.6E-02	2	0.1E-02	1.0E-02	0.0E-05	1.0E-07	0.5	1.4E-04	3.6E-07	
Arsenic (As)	3.0E-03	1.0E-01	3.0E-02	0.1	1.0E+00	3.0E-01	5.7E-05	1.4E-07	0.01	8.7E-03	1.4E-05	
Beryllium (Be)	3.0E-04	1.0E-02	3.0E-03	0.006	1.7E+00	5.0E-01	8.0E-05	1.4E-05	0.0002	2.0E-00	0.0E+00	
Cadmium (Cd)	5.0E-02	1.7E+00	5.0E-01	0.2	8.5E+00	2.5E+00	8.3E-04	2.3E-06	0.005	1.5E-01	4.0E-04	
Cerium (Ce)	1.0E+00	0.0E+01	1.7E+01	70	0.5E-01	2.5E-01	3.3E-02	7.0E-05	2	1.7E-02	3.0E-05	
Cobalt (Co)	1.3E-03	4.5E-02	1.3E-02	0.05	9.0E-01	2.6E-01	2.0E-05	5.0E-08	0.05	5.6E-04	1.3E-06	
Cyanide	5.5E+00	1.0E+02	5.5E+01	5	3.0E+01	1.1E+01	1.0E-01	2.4E-04	5	2.0E-02	4.0E-05	
Mercury (Hg)	3.1E-01	1.1E+01	3.1E+00	0.076	1.4E+02	4.1E+01	8.0E-03	1.4E-03	0.05	1.5E-01	0.0E-04	
Neodymium (Nd)	1.4E-01	4.8E+00	1.4E+00	72	0.0E-02	2.0E-02	2.7E-03	0.0E-06	3.5	7.0E-04	1.0E-06	
Oxalate	0.0E+00	0.0E+00	0.0E+00	4	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1	0.0E+00	0.0E+00	
Non-oxalate TOC	4.0E+01	1.4E+03	4.0E+02	3	4.0E+02	1.3E+02	7.0E-01	1.0E-00	2.5	3.0E-01	7.0E-04	
Selenium (Se)	0.2E-02	2.0E+00	0.1E-01	0.2	1.4E+01	4.1E+00	1.0E-03	3.7E-00	0.2	7.0E-03	1.0E-05	
Tellurium (Te)	0.0E+00	0.0E+00	0.0E+00	0.13	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.1	0.0E+00	0.0E+00	
Thallium (Tl)	3.2E-03	1.1E-01	3.2E-02	0.3	3.0E-01	1.1E-01	0.1E-05	1.4E-07	0.1	0.1E-04	1.4E-06	
Uranium (U)	1.0E+00	0.1E+01	1.0E+01	1	0.1E+01	1.0E+01	3.4E-02	0.1E-06	0.2	1.7E-01	4.1E-04	
Vanadium (V)	4.1E-03	1.4E-01	4.1E-02	1.2	1.2E-01	3.4E-02	7.0E-05	1.0E-07	0.03	2.0E-03	0.5E-06	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	7.2E+02	2.1E+02	N/A	N/A	N/A	0.4E-01	2.0E-03	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	1.4E-03	4.8E-03	N/A	N/A	N/A	1.2E+00	0.0E+02	

* In units of L/s for steady state releases and units of L for puff releases.
** Lower of PEL-TWA and ERPG-1 used for offsite risk guide.

Table E-1B. Toxic Chemical Consequences — Unit Releases Single Shell Liquids 10-4 to 10-2 yr-1 Frequency - Toxics.

TABLE E-1B
Tank/Waste Type: Single Shell Tanks/Liquids
Frequency: 10-4 to 10-2 per year
Analyte type: Toxics

Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Release Height: Ground Level

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.6s / < 3.6s		X/Qs: 3.4E-2 s/m3 / 0.9E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s		X/Qs: 1.4E-5 s/m3 / 4.3E-5/m3	
Analyte	Analyte Concentration (mL)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Antimony (Sb)	3.0E-03	1.2E-01	3.4E-02	40	3.1E-06	0.0E+00	0.0E+00	1.6E-07	2	3.4E-08	0.0E+00
Arsenic (As)	3.0E-03	1.4E-01	3.0E-02	7	1.8E-05	4.3E-08	8.7E-06	1.4E-07	0.1	8.7E-04	1.4E-08
Beryllium (Be)	3.0E-04	1.0E-02	3.0E-03	0.028	4.1E-01	1.2E-01	5.8E-08	1.4E-08	0.008	0.0E+00	2.8E-06
Cadmium (Cd)	5.0E-02	1.7E+00	5.0E-01	1	1.7E+00	5.0E-01	9.6E-04	2.3E-08	0.2	4.8E-08	1.1E-05
Cerium (Ce)	1.4E+00	8.0E+01	1.7E+01	500	1.2E-01	3.5E-08	3.3E-02	7.8E-06	70	4.6E-04	1.1E-08
Cobalt (Co)	1.3E-03	4.5E-02	1.3E-02	0.2	2.2E-01	0.0E-02	2.2E-05	5.1E-08	0.05	5.0E-04	1.2E-08
Cyanide	5.3E+00	1.8E+02	5.3E+01	41	4.4E+00	1.3E+00	1.0E-01	2.4E-04	5	2.0E-06	4.6E-05
Mercury (Hg)	3.1E-01	1.1E+01	3.1E+00	0.1	1.1E+02	9.1E+01	8.8E-03	1.4E-06	0.075	7.2E-02	1.6E-04
Neodymium (Nd)	1.4E-01	4.9E+00	1.4E+00	804	9.7E-03	2.8E-03	2.7E-08	6.5E-06	72	3.3E-08	9.0E-08
Oxalate	0.0E+00	0.0E+00	0.0E+00	20	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4	0.0E+00	0.0E+00
TOC-Oxalate	4.0E+01	1.4E+03	4.0E+02	15	9.1E+01	2.6E+01	7.9E-01	1.8E-03	3	2.2E-01	5.0E-04
Selenium (Se)	8.2E-02	2.8E+00	8.1E-01	0.4	7.0E+00	2.0E+00	1.1E-03	2.7E-06	0.2	7.3E-06	1.6E-05
Tellurium (Te)	0.0E+00	0.0E+00	0.0E+00	0.3	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.13	0.0E+00	0.0E+00
Thallium (Tl)	3.2E-03	1.1E-01	3.2E-02	2	5.4E-02	1.6E-02	6.1E-06	1.4E-07	0.3	2.0E-04	4.6E-07
Uranium (U)	1.0E+00	6.1E+01	1.0E+01	10	6.1E+00	1.0E+00	3.4E-02	8.1E-05	1	3.4E-02	8.1E-05
Vanadium (V)	4.1E-03	1.4E-01	4.1E-02	11	1.3E-02	3.7E-03	7.8E-06	1.8E-07	1.2	6.5E-03	1.5E-07
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	2.2E+02	6.3E+01	N/A	N/A	N/A	4.0E-01	9.5E-04
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	4.6E-03	1.6E-02	N/A	N/A	N/A	2.5E+00	1.1E+03

* In units of L/s for steady state releases and units of L for puff releases.

Table E-1C. Toxic Chemical Consequences -- Unit Releases Single Shell Liquids 10-6 to 10-4 yr-1 Frequency - Toxics.

TABLE E-1C Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: Single Shell Tanks/Liquids — Chemical Inventory: Inventory based on WHC-SD-WM-ER-400

Frequency: 10-6 to 10-4 per year — Release Height: Ground Level

Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.5h		X/Q: 3.4E-2 s/m3		Release Type: Steady State / Puff		Release Duration: > 480 s		X/Q: 1.8E-4 s/m3	
				< 3.5h		9.0E-3/m3				< 480 s		4.8E-3/m3	
Analyte	Analyte Concentration (pCi)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	3.0E-09	1.3E-01	3.0E-02	70	1.7E-03	5.1E-04		6.4E-05	1.0E-07	40	1.7E-06	4.1E-09	
Arsenic (As)	3.0E-09	1.0E-01	3.0E-02	40	2.5E-03	7.4E-04		8.7E-05	1.4E-07	7	0.1E-06	1.0E-08	
Beryllium (Be)	3.0E-04	1.0E-02	3.0E-03	0.1	1.0E-01	3.0E-02		8.8E-03	1.4E-05	0.08	2.3E-04	8.8E-07	
Cadmium (Cd)	5.0E-02	1.7E+00	8.0E-01	10	1.7E-01	5.0E-02		9.8E-04	2.3E-06	1	0.8E-04	2.3E-08	
Cerium (Ce)	1.8E+00	6.0E+01	1.7E+01	700	0.9E-02	2.5E-02		3.3E-02	7.8E-05	500	0.7E-05	1.8E-07	
Cobalt (Co)	1.3E-08	4.8E-02	1.3E-02	6	5.8E-03	1.8E-03		2.8E-05	8.8E-08	0.3	1.3E-04	3.6E-07	
Cyanide	8.3E+00	1.4E+02	8.3E+01	200	9.0E-01	2.6E-01		1.0E-01	2.4E-04	41	2.8E-03	6.8E-06	
Mercury (Hg)	3.1E-01	1.1E+01	3.1E+00	14	7.8E-01	2.3E-01		8.8E-03	1.4E-05	0.1	8.8E-02	1.4E-04	
Neodymium (Nd)	1.4E-01	4.9E+00	1.4E+00	720	6.8E-03	2.0E-03		2.7E-03	6.1E-06	604	5.4E-06	1.2E-08	
Oxalate	0.0E+00	0.0E+00	0.0E+00	40	0.0E+00	0.0E+00		0.0E+00	0.0E+00	20	0.0E+00	0.0E+00	
TOC-Oxalate	4.0E+01	1.4E+03	4.0E+02	80	2.7E+01	7.9E+00		7.8E-01	1.8E-03	18	0.1E-02	1.8E-04	
Selenium (Se)	8.2E-02	2.8E+00	8.1E-01	2	1.4E+00	4.1E-01		1.4E-03	3.7E-06	0.4	3.5E-03	8.1E-06	
Tellurium (Te)	0.0E+00	0.0E+00	0.0E+00	1.4	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.3	0.0E+00	0.0E+00	
Thallium (Tl)	3.2E-03	1.1E-01	3.2E-02	20	5.4E-03	1.6E-03		0.1E-05	1.4E-07	2	3.0E-05	7.2E-08	
Uranium (U)	1.8E+00	6.1E+01	1.8E+01	20	3.1E+00	0.9E-01		3.4E-02	0.1E-05	10	3.4E-03	0.1E-06	
Vanadium (V)	4.1E-03	1.4E-01	4.1E-02	40	3.5E-03	1.0E-03		7.5E-05	1.3E-07	11	7.1E-06	1.7E-08	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	3.4E+01	9.8E+00		N/A	N/A	N/A	1.3E-01	2.3E-04	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	3.0E-02	1.0E-01		N/A	N/A	N/A	0.3E+00	0.3E+00	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-1D. Toxic Chemical Consequences — Unit Releases Single Shell Liquids 10-2 to 1 yr-1 Frequency - Corrosives.

TABLE E-1D Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: Single Shell Tanks/Liquids — Chemical Inventory: Inventory based on WHC-SD-WM-ER-400

Frequency: 10-2 to 10-0 per year — Release Height: Ground Level

Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.5s / < 3.5s		X/Qs: 3.4E-2 s/m3 / 9.8E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s		X/Qs: 1.8E-5 s/m3 / 4.8E-6/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide** PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	5.1E-01	1.7E+01	5.0E+00	0.46	3.8E+01	1.1E+01		9.7E-03	2.9E-06	0.46	2.1E-02	6.0E-06	
Barium (Ba)	5.9E-02	1.8E+00	5.2E-01	0.5	2.7E-01	7.7E-02		1.6E-03	2.4E-06	0.5	2.8E-03	4.8E-06	
Calcium (Ca)	1.1E+00	3.7E+01	1.1E+01	1	3.7E+01	1.1E+01		2.1E-02	6.6E-06	1	2.1E-02	6.6E-06	
Chromium (Cr+3)	0.0E+00	0.0E+00	0.0E+00	2.5	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.5	0.0E+00	0.0E+00	
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	50	0.0E+00	0.0E+00		0.0E+00	0.0E+00	2.5	0.0E+00	0.0E+00	
Lanthanum (La)	1.9E-01	6.6E+00	1.9E+00	0.9	9.4E-01	2.7E-01		3.6E-03	0.0E-06	0.9	5.9E-04	1.8E-06	
Sodium (Na - NaOH)	2.1E+02	7.1E+03	2.1E+03	1.2	6.0E+03	1.7E+03		4.0E+00	0.0E-03	1.2	3.3E+00	7.8E-03	
Sod. Hydrxde (NaOH)	2.1E+02	7.1E+03	2.1E+03	2	3.6E+03	1.0E+03		4.0E+00	0.0E-03	2	2.0E+00	4.7E-03	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	9.6E+03	2.8E+03		N/A	N/A	N/A	5.4E+00	1.3E-02	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	1.0E-04	3.6E-04		N/A	N/A	N/A	1.8E-01	7.8E+01	

* In units of L/s for steady state releases and units of L for puff releases.

** lower of PEL-TWA and ERPG-1 used for risk guide

Table E-1E. Toxic Chemical Consequences — Unit Releases Single Shell Liquids 10-4 to 10-2 yr-1 Frequency - Corrosives.

TABLE E-1E Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: Single Shell Tanks/Liquids — Chemical Inventory: Invetory from WHC-SD-WM-ER-400

Frequency: 10-4 to 10-2 per year — Release Height: Ground Level

Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)					OFFSITE (Site Boundary)				
		Release Type		Release Duration		X/Qs	Release Type		Release Duration		X/Qs
		Steady State		> 3.5s		3.4E-2 s/m3	Steady State		> 420 s		1.9E-5 s/m3
		Puff		< 3.5s		9.9E-3/m3	Puff		< 420 s		4.8E-8/m3
		C	D	E	F	G	H	I	J	K	L
Analyte	Analyte Concentration (g/L)	Steady State Release Consequence (mg/m3)	Puff Release Consequence (mg/m3)	Risk Guide ERPG-2 (mg/m3)	Fraction of Risk Guide Steady State (unitless)	Fraction of Risk Guide Puff (unitless)	Steady State Release Consequence (mg/m3)	Puff Release Consequence (mg/m3)	Risk Guide ERPG-1 (mg/m3)	Fraction of Risk Guide Steady State (unitless)	Fraction of Risk Guide Puff (unitless)
Ammonia (NH3)	5.1E-01	1.7E+01	5.0E+00	9.2	1.9E+00	5.5E-01	9.7E-03	2.3E-05	0.46	2.1E-02	5.0E-05
Barium (Ba)	5.2E-02	1.8E+00	5.2E-01	138	1.3E-02	3.8E-03	1.0E-03	2.4E-06	6.8	1.5E-04	3.5E-07
Calcium (Ca)	1.1E+00	3.7E+01	1.1E+01	22	1.7E+00	5.0E-01	2.1E-02	5.0E-05	1	2.1E-02	5.0E-05
Chromium (Cr+3)	0.0E+00	0.0E+00	0.0E+00	51.5	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.6	0.0E+00	0.0E+00
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	600	0.0E+00	0.0E+00	0.0E+00	0.0E+00	80	0.0E+00	0.0E+00
Lanthanum (La)	1.9E-01	6.5E+00	1.9E+00	137	4.7E-02	1.4E-02	3.6E-03	8.6E-06	6.9	5.2E-04	1.2E-06
Sodium (Na - NaOH)	2.1E+02	7.1E+03	2.1E+03	23	3.1E+02	9.0E+01	4.0E+00	9.5E-03	1.2	3.3E+00	7.9E-03
Sod. Hydrxde (NaOH)	2.1E+02	7.1E+03	2.1E+03	40	1.8E+02	5.2E+01	4.0E+00	9.5E-03	2	2.0E+00	4.7E-03
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	4.9E+02	1.4E+02	N/A	N/A	N/A	5.4E+00	1.3E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	2.0E-03	7.0E-03	N/A	N/A	N/A	1.9E-01	7.9E+01

* In units of L/s for steady state releases and units of L for puff releases.

Table E-1F. Toxic Chemical Consequences — Unit Releases Single Shell Liquids 10-6 to 10-4 yr-1 Frequency - Corrosives.

TABLE E-1F Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: Single Shell Tanks/Liquids — Chemical Inventory: 100% bounding per KEH inventory data

Frequency: 10-6 to 10-4 per year — Release Height: Ground Level

Analyte type: Corrosives/Antacids

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.5s / < 3.5s		XOr: 3.4E-2 s/m3 / 9.9E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s		XOr: 1.8E-5 s/m3 / 4.8E-4m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	8.1E-01	1.7E+01	5.0E+00	20	7.8E-01	2.5E-01		8.7E-03	2.5E-03	8.2	1.1E-03	3.0E-04	
Barium (Ba)	5.9E-02	1.8E+00	5.2E-01	344	8.5E-03	1.5E-03		1.0E-03	2.4E-04	188	7.3E-06	1.7E-06	
Calcium (Ca)	1.1E+00	3.7E+01	1.1E+01	84	4.5E-01	2.2E-01		2.1E-02	5.4E-03	38	8.5E-04	2.2E-04	
Chromium (Cr+3)	0.0E+00	0.0E+00	0.0E+00	120	0.0E+00	0.0E+00		0.0E+00	0.0E+00	51.5	0.0E+00	0.0E+00	
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	800	0.0E+00	0.0E+00		0.0E+00	0.0E+00	800	0.0E+00	0.0E+00	
Lanthanum (La)	1.9E-01	6.5E+00	1.9E+00	343	1.9E-02	5.5E-03		3.6E-03	8.9E-04	137	2.6E-05	6.5E-06	
Sodium (Na - NaOH)	2.1E+02	7.1E+03	2.1E+03	98	1.2E+02	3.6E+01		4.0E+00	9.8E-03	25	1.7E-01	4.1E-04	
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	100	7.1E+01	2.1E+01		4.0E+00	9.8E-03	40	1.0E-01	2.4E-04	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	2.0E+02	5.7E+01		N/A	N/A	N/A	2.8E-01	6.8E-04	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	5.1E-03	1.8E-02		N/A	N/A	N/A	3.6E+00	1.5E+03	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-2A. Toxic Chemical Consequences — Unit Releases Single Shell Solids 10-2 to 1 yr-1 Frequency - Toxics

TABLE E-2A
Tank/Waste Type: Single Shell Tanks/Solids
Frequency: 10-2 to 10-0 per year
Analyte type: Toxics
Todo Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Chemical Inventory: Inventory from WHC-SD-WM-ER-400
Release Height: Ground Level

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.5s / < 3.5s		X/Qs: 3.4E-3 s/m3 / 9.8E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s		X/Qs: 1.9E-5 s/m3 / 4.8E-5/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	1.0E+00	5.0E+01	1.4E+01	2	2.5E+01	7.2E+00		2.5E-02	6.9E-03	0.5	5.0E-02	1.3E-04	
Arsenic (As)	1.2E+00	4.1E+01	1.5E+01	0.1	4.1E+02	1.5E+02		2.5E-02	8.4E-03	0.01	2.5E+00	6.4E-04	
Beryllium (Be)	2.8E-02	8.7E-01	2.8E-01	0.005	1.8E+02	4.9E+01		4.6E-04	1.5E-04	0.002	2.4E-01	6.3E-04	
Cadmium (Cd)	1.7E+00	5.8E+01	1.7E+01	0.2	2.9E+02	8.4E+01		3.3E-02	7.7E-03	0.005	1.0E+00	1.8E-02	
Cerium (Ce)	9.0E-01	3.1E+01	8.0E+00	70	4.4E-01	1.3E-01		1.7E-02	4.1E-03	2	5.6E-03	2.8E-05	
Cobalt (Co)	5.4E-01	1.8E+01	5.2E+00	0.05	3.7E+02	1.1E+02		1.0E-02	2.4E-03	0.05	2.1E-01	4.8E-04	
Cyanide	2.8E+00	9.5E+01	2.4E+01	5	1.9E+01	6.8E+00		6.8E-02	1.3E-04	5	1.1E-03	2.8E-05	
Mercury (Hg)	5.4E+01	1.8E+03	5.5E+02	0.075	2.4E+04	7.1E+03		1.0E+00	2.4E-03	0.05	2.1E+01	4.8E-02	
Neodymium (Nd)	2.3E-01	7.8E+00	2.2E+00	72	1.1E-01	3.3E-02		4.4E-03	1.0E-05	2.5	1.3E-03	3.0E-05	
Oxalate	2.8E+02	9.4E+03	2.7E+03	4	2.3E+03	6.9E+02		5.3E+00	1.2E-02	1	6.5E+00	1.3E-02	
TOC	7.8E+01	2.6E+03	7.4E+02	3	8.8E+02	2.6E+02		1.4E+00	3.4E-03	2.5	8.1E-01	1.4E-03	
Selenium (Se)	3.5E+00	1.2E+02	3.3E+01	0.2	6.0E+02	1.7E+02		8.7E-02	1.3E-04	0.2	3.3E-01	7.3E-04	
Tellurium (Te)	2.0E-01	6.7E+00	1.9E+00	0.13	5.1E+01	1.5E+01		3.7E-03	8.4E-06	0.1	8.1E-02	0.0E-05	
Thallium (Tl)	1.2E+00	4.1E+01	1.2E+01	0.3	1.4E+02	4.0E+01		2.5E-02	5.4E-05	0.1	2.3E-01	5.4E-04	
Uranium (U)	2.8E+02	9.7E+03	2.8E+03	1	9.7E+03	2.8E+03		5.4E+00	1.3E-02	0.2	2.7E+01	6.4E-02	
Vanadium (V)	3.3E-02	1.1E+00	3.3E-01	1.2	9.4E-01	2.7E-01		8.3E-04	1.8E-06	0.03	2.1E-02	5.0E-05	
SUM OF FRACTIONS		N/A	N/A	N/A	3.8E+04	1.1E+04		N/A	N/A	N/A	8.0E+01	1.9E-01	
ALLOWABLE RELEASE*		N/A	N/A	N/A	2.5E-05	8.7E-05		N/A	N/A	N/A	1.4E-02	8.7E+00	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-2B. Toxic Chemical Consequences — Unit Releases Single Shell Solids 10-4 to 10-2 yr-1 Frequency - Toxics.

TABLE E-2B Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: Single Shell Tanks/Solids — Chemical Inventory: Inventory from WHC-SD-WM-ER-400

Frequency: 10-4 to 10-2 per year — Release Height: Ground Level

Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.5s / < 3.5s		X/Q: 3.4E-3 s/m3 / 9.9E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s		X/Q: 1.1E-5 s/m3 / 4.8E-5/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Antimony (Sb)	1.5E+00	5.0E+01	1.4E+01	40	1.2E+00	3.0E-01	2.8E-02	6.6E-05	2	1.4E-02	3.3E-05
Arsenic (As)	1.2E+00	4.1E+01	1.2E+01	7	5.8E+00	1.7E+00	2.3E-02	5.4E-05	0.1	2.2E-01	5.4E-04
Beryllium (Be)	2.8E-02	8.7E-01	2.5E-01	0.0035	3.5E+01	1.0E+01	4.8E-04	1.1E-06	0.005	0.11E-02	1.1E-04
Cadmium (Cd)	1.7E+00	5.8E+01	1.7E+01	1	5.8E+01	1.7E+01	3.2E-02	7.7E-05	0.2	1.1E-01	3.1E-04
Cerium (Ce)	9.0E-01	3.1E+01	9.0E+00	500	6.1E-02	1.8E-02	1.7E-02	4.1E-05	70	2.4E-04	5.5E-07
Cobalt (Co)	5.4E-01	1.8E+01	5.3E+00	0.2	9.2E+01	2.7E+01	1.0E-02	2.4E-05	0.05	2.1E-01	4.8E-04
Cyanide	2.8E+00	9.5E+01	2.8E+01	41	2.3E+00	6.8E-01	5.3E-02	1.3E-04	5	1.1E-02	2.5E-05
Mercury (Hg)	8.4E+01	1.8E+03	5.3E+02	0.1	1.8E+04	5.3E+03	1.0E+00	2.4E-03	0.075	1.4E+01	3.3E-02
Neodymium (Nd)	2.3E-01	7.8E+00	2.3E+00	504	1.6E-02	4.8E-03	4.4E-03	1.0E-05	72	0.1E-05	1.4E-07
Oxalate	2.8E+02	9.4E+03	2.7E+03	20	4.7E+02	1.4E+02	5.2E+00	1.2E-02	4	1.3E+00	3.1E-03
TOC	7.5E+01	2.6E+03	7.4E+02	15	1.7E+02	5.0E+01	1.4E+00	3.4E-03	3	4.8E-01	1.1E-03
Selenium (Se)	3.5E+00	1.2E+02	3.5E+01	0.4	3.0E+02	8.7E+01	0.7E-02	1.6E-04	0.2	3.3E-01	7.5E-04
Tellurium (Te)	2.0E-01	6.7E+00	1.9E+00	0.3	2.2E+01	6.8E+00	3.7E-03	8.8E-06	0.13	2.2E-02	5.0E-05
Thallium (Tl)	1.2E+00	4.1E+01	1.2E+01	2	2.0E+01	5.9E+00	2.3E-02	5.4E-05	0.3	7.6E-02	1.8E-04
Uranium (U)	2.8E+02	9.7E+03	2.8E+03	10	0.7E+02	2.0E+02	5.4E+00	1.3E-02	1	5.4E+00	1.2E-02
Vanadium (V)	3.3E-02	1.1E+00	3.3E-01	11	1.0E-01	3.0E-02	0.3E-04	1.5E-06	1.2	0.2E-04	1.1E-08
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	2.0E+04	0.0E+03	N/A	N/A	N/A	2.2E+01	5.1E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	4.9E-05	1.7E-04	N/A	N/A	N/A	4.5E-02	1.3E+01

* In units of L/s for steady state releases and units of L for puff releases.

Table E-2C. Toxic Chemical Consequences — Unit Releases Single Shell Solids 10-6 to 10-4 yr-1 Frequency -Toxics

TABLE E-2C Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: Single Shell Tanks/Solids Chemical Inventory: Inventory for WHC-SD-WM-ER-400
Frequency: 10-6 to 10-4 per year Release Height: Ground Level
Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.5s / < 3.5s		X/Qs: 3.4E-2 s/m3 / 9.9E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s			X/Qs: 1.9E-5 s/m3 / 4.5E-6/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)		L Fraction of Risk Guide Puff (unitless)
Antimony (Sb)	1.5E+00	5.0E+01	1.4E+01	70	7.1E-01	2.1E-01		2.3E-02	6.6E-03	40	5.8E-04		1.4E-04
Arsenic (As)	1.2E+00	4.1E+01	1.2E+01	40	1.0E+00	3.0E-01		2.3E-02	6.4E-03	7	3.3E-03		7.7E-04
Beryllium (Be)	2.0E-02	8.7E-01	2.5E-01	0.1	8.7E+00	2.5E+00		4.0E-04	1.3E-04	0.035	1.0E-02		4.0E-05
Cadmium (Cd)	1.7E+00	5.8E+01	1.7E+01	10	5.8E+00	1.7E+00		3.3E-02	7.7E-03	1	3.3E-02		7.7E-05
Cerium (Ce)	9.0E-01	3.1E+01	8.8E+00	700	4.4E-02	1.3E-02		1.7E-02	4.1E-03	500	3.4E-05		8.1E-06
Cobalt (Co)	5.4E-01	1.8E+01	5.3E+00	6	2.9E+00	8.7E-01		1.0E-02	2.4E-03	0.2	5.1E-02		1.2E-04
Cyanide	2.4E+00	8.8E+01	2.4E+01	200	4.8E-01	1.4E-01		5.3E-02	1.3E-04	41	1.3E-03		3.1E-06
Mercury (Hg)	5.4E+01	1.8E+03	5.3E+02	14	1.3E+02	3.8E+01		1.0E+00	2.4E-03	0.1	1.4E+01		2.4E-02
Neodymium (Nd)	2.3E-01	7.8E+00	2.3E+00	720	1.1E-02	3.2E-03		4.4E-03	1.0E-03	504	8.7E-06		2.1E-06
Oxalate	2.0E+02	9.4E+03	2.7E+03	40	2.3E+02	6.8E+01		5.2E+00	1.2E-02	20	2.6E-01		6.3E-04
TOC	7.3E+01	2.8E+03	7.4E+02	80	8.1E+01	1.9E+01		1.4E+00	3.4E-03	18	9.0E-02		2.2E-04
Selenium (Se)	3.5E+00	1.2E+02	3.5E+01	2	6.0E+01	1.7E+01		8.7E-02	1.1E-04	0.4	1.7E-01		3.9E-04
Tellurium (Te)	2.0E-01	6.7E+00	1.9E+00	1.4	4.8E+00	1.4E+00		3.7E-03	8.8E-06	0.3	1.2E-02		2.9E-05
Thallium (Tl)	1.2E+00	4.1E+01	1.2E+01	20	2.0E+00	5.8E-01		2.3E-02	5.4E-05	2	1.1E-02		2.7E-05
Uranium (U)	2.8E+02	9.7E+03	2.8E+03	20	4.8E+02	1.4E+02		5.4E+00	1.3E-02	10	8.4E-01		1.9E-03
Vanadium (V)	3.3E-02	1.1E+00	3.3E-01	40	2.8E-02	8.2E-03		8.3E-04	1.8E-06	11	5.7E-05		1.4E-07
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	9.8E+02	2.9E+02		N/A	N/A	N/A	1.1E+01		2.7E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	1.0E-03	3.5E-03		N/A	N/A	N/A	8.7E-02		3.7E+01

* In units of L/s for steady state releases and units of L for puff releases.

Table E-2D. Toxic Chemical Consequences — Unit Releases Single Shell Solids 10-2 to 1 yr-1 Frequency - Corrosives.

TABLE E-2D Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: Single Shell Tanks/Solids Chemical Inventory: Inventory from WHC-SD-WM-ER-400
Frequency: 10-2 to 10-0 per year Release Height: Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type		Release Duration			χ/Qs	Release Type			Release Duration		χ/Qs
		Steady State		> 3.5h			3.4E-2 s/m3	Steady State			> 420 s		1.9E-5 s/m3
		Puff		< 3.5h			0.9E-3/m3	Puff			< 420 s		4.9E-6/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide** PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	3.3E-01	1.1E+01	3.3E+00	0.48	2.4E+01	7.1E+00		0.8E-03	1.5E-06	0.48	1.4E-02	3.1E-06	
Barium (Ba)	4.0E+01	1.4E+03	3.8E+02	0.0	2.8E+02	8.8E+01		7.4E-01	1.8E-04	0.5	1.4E+00	3.8E-04	
Calcium (Ca)	5.1E+01	1.7E+03	5.0E+02	1	1.7E+03	5.0E+02		0.7E-01	2.3E-03	1	0.7E-01	2.3E-03	
Chromium (Cr+3)	6.8E+01	2.3E+03	0.4E+02	2.0	0.0E+02	2.0E+02		1.3E+00	3.1E-03	0.5	2.8E+00	6.5E-03	
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	80	0.0E+00	0.0E+00		0.0E+00	0.0E+00	5.2	0.0E+00	0.0E+00	
Lanthanum (La)	5.0E+01	1.7E+03	5.0E+02	0.0	2.8E+02	7.2E+01		0.9E-01	2.3E-03	5.0	1.4E-01	3.3E-04	
Sodium (Na - NaOH)	4.8E+02	1.6E+04	4.8E+03	1.2	1.4E+04	4.0E+03		9.1E+00	2.2E-02	1.2	7.4E+00	1.8E-02	
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	2	3.8E+03	1.0E+03		4.0E+00	9.5E-05	2	2.0E+00	4.7E-03	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	2.0E+04	5.8E+03		N/A	N/A	N/A	1.8E+01	3.3E-02	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	4.9E-05	1.7E-04		N/A	N/A	N/A	0.7E-02	2.8E+01	

* In units of L/s for steady state releases and units of L for puff releases.
** lower of PEL-TWA and ERPG-1 are used for offsite calculation

Table E-2E. Toxic Chemical Consequences — Unit Releases Single Shell Solids 10-4 to 10-2 yr-1 Frequency - Corrosives.

TABLE E-2E Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: Single Shell Tanks/Solids Chemical Inventory: Inventory from WHC-SD-WM-ER-400
Frequency: 10-4 to 10-2 per year Release Height: Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)				
		Release Type: Steady State Puff		Release Duration: > 3.5s / < 3.5s		X/Qs: 3.4E-2 s/m3 / 9.0E-3/m3		Release Type: Steady State Puff		Release Duration: > 420 s / < 420 s		X/Qs: 1.9E-5 s/m3 / 4.8E-5/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)-s	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)-s	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Ammonia (NH3)	3.3E-01	1.1E+01	3.3E+00	0.2	1.3E+00	3.3E-01		6.3E-03	1.8E-03	0.40	1.4E-02	3.8E-03
Barium (Ba)	4.0E+01	1.4E+03	3.8E+02	138	9.8E+00	2.8E+00		7.0E-01	1.8E-03	8.0	1.1E-01	2.8E-04
Cesium (Cs)	5.1E+01	1.7E+03	5.0E+02	22	7.5E+01	2.5E+01		9.7E-01	2.3E-03	1	9.7E-01	2.3E-03
Chromium (Cr+3)	6.8E+01	2.3E+03	6.8E+02	51.5	4.5E+01	1.3E+01		1.3E+00	3.1E-03	2.0	6.6E-01	1.5E-03
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	600	0.0E+00	0.0E+00		0.0E+00	0.0E+00	80	0.0E+00	0.0E+00
Lanthanum (La)	5.0E+01	1.7E+03	5.0E+02	157	1.2E+01	3.9E+00		9.8E-01	2.3E-03	8.0	1.4E-01	3.3E-04
Sodium (Na - NaOH)	4.8E+02	1.6E+04	4.8E+03	23	7.1E+02	2.1E+02		0.1E+00	2.3E-02	1.1	7.8E+00	1.8E-02
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	40	1.8E+02	5.8E+01		4.0E+00	0.8E-03	2	2.0E+00	4.7E-03
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	1.0E+03	3.0E+02		N/A	N/A	N/A	1.1E+01	2.7E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	9.7E-04	3.3E-03		N/A	N/A	N/A	9.1E-02	3.7E+01

* In units of L/s for steady state releases and units of L for puff releases.

Table E-2F. Toxic Chemical Consequences — Unit Releases Single Shell Solids 10-6 to 10-4 yr-1 Frequency - Corrosives.

TABLE E-2F
Tank/Waste Type: Single Shell Tanks/Solids
Frequency: 10-6 to 10-4 per year
Analyte type: Corrosives/Irritants

Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Chemical Inventory: Inventory from WHC-SD-WM-ER-400
Release Height: Ground Level

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.5s / < 3.5s		X/Qs: 3.4E-2 s/m3 / 9.9E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s			X/Qs: 1.4E-5 s/m3 / 4.8E-4/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)		L Fraction of Risk Guide Puff (unitless)
Ammonia (NH3)	9.3E-01	1.1E+01	3.9E+00	23	4.8E-01	1.4E-01		6.9E-03	1.8E-05	83	8.4E-04		1.4E-03
Barium (Ba)	4.0E+01	1.4E+03	3.9E+02	344	3.9E+00	1.1E+00		7.8E-01	1.8E-03	158	5.0E-03		1.3E-03
Calcium (Ca)	8.1E+01	1.7E+03	5.6E+02	54	3.2E+01	9.4E+00		8.7E-01	2.5E-03	22	4.4E-02		1.0E-04
Chromium (Cr+3)	8.4E+01	2.2E+03	6.4E+02	199	1.4E+01	3.9E+00		1.4E+00	3.1E-03	81.5	2.3E-02		6.0E-05
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	800	0.0E+00	0.0E+00		0.0E+00	0.0E+00	800	0.0E+00		0.0E+00
Lanthanum (La)	5.0E+01	1.7E+03	5.0E+02	343	5.0E+00	1.4E+00		9.9E-01	2.3E-03	137	5.8E-03		1.3E-05
Sodium (Na - NaOH)	4.8E+02	1.8E+04	4.8E+03	58	2.4E+02	6.8E+01		9.1E+00	2.3E-02	23	4.8E-01		9.4E-04
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	100	7.1E+01	2.1E+01		4.0E+00	9.5E-03	40	1.6E-01		2.4E-04
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	4.1E+02	1.2E+02		N/A	N/A	N/A	8.6E-01		1.4E-03
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	2.4E-03	8.3E-03		N/A	N/A	N/A	1.7E+00		7.2E+02

* In units of L/s for steady state releases and units of L for puff releases.

Table E-3A. Toxic Chemical Consequences — Unit Releases Double Shell Liquids 10-2 to 1 yr-1 Frequency - Toxics.

TABLE E-3A Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: Double Shell Tanks/Liquids Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-2 to 10-0 per year Release Height: Ground Level
Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type			Release Duration		X/Qs	Release Type					X/Qs
		Steady State			> 3.6s		5.4E-2 s/m3	Steady State		Release Duration			1.8E-5 s/m3
		Puff			< 3.6s		0.0E-3/m3	Puff		> 480 s			4.8E-5/m3
										< 480 s			
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide EPPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk** Guide PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	1.6E-03	2.5E-01	6.5E-02	2	1.1E-01	3.5E-02		1.3E-04	2.1E-07	0.5	2.4E-04	6.8E-07	
Arsenic (As)	8.7E-03	3.0E-01	8.0E-02	0.1	3.0E+00	9.4E-01		1.7E-04	3.3E-07	0.01	1.7E-02	3.1E-05	
Beryllium (Be)	3.3E-03	1.3E-01	3.8E-02	0.008	2.3E+01	6.8E+00		7.3E-05	1.7E-07	0.002	3.6E-02	8.6E-05	
Cadmium (Cd)	7.0E-02	2.4E+00	6.0E-01	0.2	1.2E+01	3.8E+00		1.3E-03	3.3E-06	0.005	2.7E-01	6.6E-04	
Cerium (Ce)	8.1E-02	2.0E+00	5.7E-01	70	2.2E-02	0.3E-03		1.1E-03	2.6E-06	2	8.0E-04	1.3E-06	
Cobalt (Co)	0.0E-03	3.0E-01	8.7E-02	0.05	0.0E+00	1.7E+00		1.7E-04	4.0E-07	0.05	5.3E-03	7.4E-06	
Cyanide	0.1E-02	3.1E+00	9.0E-01	5	0.2E-01	1.8E-01		1.7E-03	4.1E-06	5	5.3E-01	0.1E-07	
Mercury (Hg)	2.4E-04	8.3E-03	2.4E-03	0.075	1.1E-01	3.3E-02		4.6E-05	1.1E-08	0.05	0.1E-03	2.2E-07	
Neodymium (Nd)	5.0E-03	1.6E-01	5.0E-02	72	2.0E-03	7.7E-04		1.1E-04	2.6E-07	3.3	3.5E-03	7.2E-06	
Oxalate	0.0E+00	0.0E+00	0.0E+00	4	0.0E+00	0.0E+00		0.0E+00	0.0E+00	1	0.0E+00	0.0E+00	
TOC (-Oxalate C)	4.0E+01	1.4E+03	4.0E+02	3	4.5E+02	1.3E+02		7.6E-01	1.8E-03	2.5	3.0E-01	7.2E-04	
Selenium (Se)	2.5E-01	0.5E+00	2.6E+00	0.2	4.6E+01	1.4E+01		5.5E-03	1.3E-05	0.2	2.7E-03	6.5E-05	
Tellurium (Te)	2.7E-03	9.3E-02	2.7E-02	0.13	7.1E-01	2.1E-01		5.1E-05	1.2E-07	0.1	6.1E-04	1.5E-06	
Thallium (Tl)	3.7E-02	1.3E+00	3.7E-01	0.3	4.5E+00	1.3E+00		7.0E-04	1.7E-06	0.1	7.0E-03	1.7E-05	
Uranium (U)	1.1E+01	3.7E+02	1.1E+02	1	3.7E+02	1.1E+02		2.1E-01	5.0E-04	0.2	1.4E+00	2.8E-03	
Vanadium (V)	2.1E-03	7.1E-02	2.1E-02	1.2	6.0E-02	1.7E-02		4.0E-05	0.8E-08	0.05	1.3E-03	3.2E-06	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	0.2E+02	2.7E+02		N/A	N/A	N/A	1.7E+00	4.0E-00	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	1.1E-03	3.7E-06		N/A	N/A	N/A	5.9E-01	2.5E+02	

* In units of L/s for steady state releases and units of L for puff releases.
** Lower of PEL-TWA and EPPG-1 used for offsite risk guide

Table E-3B. Toxic Chemical Consequences — Unit Releases Double Shell Liquids 10-4 to 10-2 yr-1 Frequency - Toxics.

TABLE E-3B
Tank/Waste Type: Double Shell Tanks/Liquids
Frequency: 10-4 to 10-2 per year
Analyte type: Toxics

Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Release Height: Ground Level

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.5s / < 3.5s		XiOi: 3.4E-2 s/m3 / 0.0E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s			XiOi: 1.8E-5 s/m3 / 4.9E-5/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)		L Fraction of Risk Guide Puff (unitless)
Antimony (Sb)	6.4E-03	2.2E-01	6.3E-02	40	5.4E-03	1.6E-03		1.3E-04	2.3E-07	2	6.1E-03		1.4E-07
Arsenic (As)	8.7E-03	3.0E-01	8.6E-02	7	4.3E-02	1.3E-02		1.7E-04	3.1E-07	0.1	1.7E-03		3.8E-06
Beryllium (Be)	5.9E-03	1.3E-01	5.9E-02	0.025	5.2E+00	1.5E+00		7.2E-05	1.7E-07	0.008	1.4E+00		2.8E-05
Cadmium (Cd)	7.0E-02	2.4E+00	6.9E-01	1	2.4E+00	0.9E-01		1.3E-03	3.2E-03	0.2	0.7E-03		1.6E-05
Cerium (Ce)	6.8E-02	2.0E+00	5.7E-01	500	3.9E-03	1.1E-03		1.1E-00	2.4E-03	70	1.4E-03		3.7E-08
Cobalt (Co)	0.8E-03	3.0E-01	8.7E-02	0.2	1.5E+00	4.4E-01		1.7E-04	4.0E-07	0.03	5.3E-03		7.3E-06
Cyanide	9.1E-02	3.1E+00	9.0E-01	41	7.6E-02	2.2E-02		1.7E-03	4.1E-03	5	3.5E-04		8.2E-07
Mercury (Hg)	2.4E-04	8.2E-03	2.4E-03	0.1	0.5E-02	2.4E-02		4.6E-09	1.1E-08	0.075	0.1E-05		1.4E-07
Neodymium (Nd)	5.0E-03	1.8E-01	5.0E-02	504	3.6E-04	1.1E-04		1.1E-04	2.8E-07	72	1.5E-03		3.8E-06
Oxalate	0.0E+00	0.0E+00	0.0E+00	20	0.0E+00	0.0E+00		0.0E+00	0.0E+00	4	0.0E+00		0.0E+00
TOC (-Oxalate C)	4.0E+01	1.4E+03	4.0E+02	15	0.1E+01	2.8E+01		7.6E-01	1.8E-03	3	2.8E-01		6.6E-04
Selenium (Se)	2.8E-01	0.8E+00	2.8E+00	0.4	2.4E+01	0.9E+00		5.3E-03	1.3E-05	0.2	2.7E-02		0.3E-05
Tellurium (Te)	2.7E-03	9.4E-02	2.7E-02	0.3	3.1E-01	0.8E-02		5.1E-05	1.3E-07	0.13	3.0E-04		0.3E-07
Thallium (Tl)	3.7E-02	1.3E+00	3.7E-01	2	0.3E-01	1.3E-01		7.0E-04	1.7E-06	0.3	2.3E-03		5.6E-06
Uranium (U)	1.1E+01	3.7E+02	1.1E+02	10	3.7E+01	1.1E+01		2.1E-01	0.0E-04	1	2.1E-01		5.0E-04
Vanadium (V)	2.1E-03	7.1E-02	2.1E-02	11	0.8E-03	1.9E-03		4.0E-06	9.6E-06	1.2	3.3E-05		7.9E-06
SUM OF FRACTIONS		N/A	N/A	N/A	1.6E+02	4.7E+01		N/A	N/A	N/A	5.2E-01		1.3E-03
ALLOWABLE RELEASE*		N/A	N/A	N/A	0.2E-03	2.1E-02		N/A	N/A	N/A	1.9E+00		8.8E+02

* In units of L/s for steady state releases and units of L for puff releases.

Table E-3C. Toxic Chemical Consequences — Unit Releases Double Shell Liquids 10-6 to 10-4 yr-1 Frequency - Toxics.

TABLE E-3C Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: Double Shell Tanks/Liquids — Chemical Inventory: — Inventory based on WHC-SD-WM-ER-400

Frequency: 10-6 to 10-4 per year — Release Height: — Ground Level

Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff			Release Duration: > 3.5s / < 3.5s		X/Q: 3.4E-2 s/m3 / 9.9E-3/m3	Release Type: Steady State / Puff			Release Duration: > 420 s / < 420 s		X/Q: 1.9E-5 s/m3 / 4.9E-6/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	6.4E-03	2.2E-01	6.5E-02	70	3.1E-03	0.1E-04		1.2E-04	2.0E-07	40	3.8E-03	7.5E-09	
Arsenic (As)	8.7E-03	3.0E-01	8.8E-02	40	7.4E-03	2.3E-03		1.7E-04	3.9E-07	7	2.4E-03	5.1E-08	
Beryllium (Be)	3.3E-03	1.3E-01	3.8E-02	0.1	1.3E+00	3.1E-01		7.2E-03	1.7E-07	0.008	2.8E-01	6.8E-06	
Cadmium (Cd)	7.0E-02	2.4E+00	6.9E-01	10	2.4E-01	0.6E-02		1.5E-03	3.5E-06	1	1.3E-03	3.2E-08	
Cerium (Ce)	5.2E-02	2.0E+00	5.7E-01	700	2.8E-03	0.3E-04		1.1E-03	2.4E-06	800	2.5E-04	5.4E-09	
Cobalt (Co)	8.8E-03	3.0E-01	8.7E-02	6	3.7E-02	1.1E-02		1.7E-04	4.0E-07	0.2	8.4E-04	2.0E-08	
Cyanide	9.1E-02	3.1E+00	9.0E-01	200	1.5E-02	4.5E-03		1.7E-03	4.1E-06	41	4.3E-03	1.0E-07	
Mercury (Hg)	2.4E-04	8.2E-03	2.4E-03	14	5.8E-04	1.7E-04		4.4E-06	1.1E-08	0.1	4.6E-06	1.1E-07	
Neodymium (Nd)	5.6E-03	1.8E-01	5.3E-02	720	2.8E-04	7.7E-05		1.1E-04	2.8E-07	804	2.1E-07	5.0E-10	
Oxalate	0.0E+00	0.0E+00	0.0E+00	40	0.0E+00	0.0E+00		0.0E+00	0.0E+00	20	0.0E+00	0.0E+00	
TOC-Oxalate C	4.0E+01	1.4E+03	4.0E+02	50	2.7E+01	7.9E+00		7.4E-01	1.8E-03	15	6.1E-02	1.3E-04	
Selenium (Se)	2.8E-01	0.9E+00	2.4E+00	2	4.4E+00	1.4E+00		8.3E-03	1.9E-05	0.4	1.8E-02	3.2E-05	
Tellurium (Te)	2.7E-03	9.5E-02	2.7E-02	1.4	0.8E-02	1.8E-02		8.1E-05	1.9E-07	0.3	1.7E-04	4.1E-07	
Thallium (Tl)	3.7E-02	1.3E+00	3.7E-01	20	0.3E-02	1.0E-02		7.0E-04	1.7E-06	2	3.8E-04	0.3E-07	
Uranium (U)	1.1E+01	3.7E+02	1.1E+02	20	1.0E+01	0.4E+00		2.1E-01	5.0E-04	10	2.1E-03	0.0E-05	
Vanadium (V)	2.1E-03	7.1E-02	2.1E-02	40	1.8E-03	5.2E-04		4.0E-05	9.5E-08	11	3.5E-03	0.4E-09	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	5.2E+01	1.5E+01		N/A	N/A	N/A	0.1E-02	2.1E-04	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	1.9E-02	6.6E-02		N/A	N/A	N/A	1.1E+01	4.7E+03	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-3D. Toxic Chemical Consequences — Unit Releases Double Shell Liquids 10-2 to 1 yr-1 Frequency - Corrosives.

TABLE E-3D
Tank/Waste Type: Double Shell Tanks/Liquids
Frequency: 10-2 to 10-0 per year
Analyte type: Corrosives/Irritants

Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Release Height: Ground Level

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)				
		Release Type		Release Duration		X/Qs	Release Type				X/Qs
		Steady State		> 3.5s		3.4E-2 s/m3	Steady State		Release Duration		1.8E-5 s/m3
		Puff		< 3.5s		9.9E-3/m3	Puff		> 480 s		4.8E-4/m3
									< 480 s		
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk** Guide PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Ammonia (NH3)	7.1E+00	2.4E+02	7.1E+01	0.40	5.9E+02	1.8E+02	1.4E+01	3.8E-04	0.40	2.5E-01	7.0E-04
Barium (Ba)	3.3E-02	1.1E+00	3.3E-01	0.5	1.7E-01	4.9E-02	6.3E-04	1.8E-03	0.5	1.3E-03	3.5E-03
Calcium (Ca)	1.3E+00	4.4E+01	1.3E+01	1	4.4E+01	1.3E+01	2.4E-02	5.8E-05	1	2.4E-02	5.8E-05
Chromium (Cr+3)	0.0E+00	0.0E+00	0.0E+00	2.0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.5	0.0E+00	0.0E+00
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	80	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.2	0.0E+00	0.0E+00
Lanthanum (La)	1.0E+00	3.4E+01	9.8E+00	0.0	4.9E+00	1.4E+00	1.9E-02	4.5E-05	0.0	1.9E-03	4.5E-05
Sodium (Na - NaOH)	2.1E+02	7.1E+03	2.1E+03	1.2	5.0E+03	1.7E+03	4.0E+00	9.6E-03	1.2	3.3E+00	7.8E-03
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	2	3.0E+03	1.0E+03	4.0E+00	9.5E-03	2	2.0E+00	4.7E-03
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	1.0E+04	2.9E+03	N/A	N/A	N/A	5.0E+00	1.3E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	9.9E-05	3.4E-04	N/A	N/A	N/A	1.8E-01	7.8E+01

* In units of L/s for steady state releases and units of L for puff releases.
** lower of PEL-TWA and ERPG-1 used for offsite risk guide

Table E-3E. Toxic Chemical Consequences — Unit Releases Double Shell Liquids 10-4 to 10-2 yr-1 Frequency - Corrosives.

TABLE E-3E Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: Double Shell Tanks/Liquids Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-4 to 10-2 per year Release Height: Ground Level
Analyte type: Corrosives/Ambients

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State Puff		Release Duration: > 3.5s / < 3.5s		X/Q: 3.4E-2 s/m3 / 9.9E-3g/m3		Release Type: Steady State Puff		Release Duration: > 420 s / < 420 s		X/Q: 1.8E-5 s/m3 / 4.8E-6g/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	7.1E+00	2.4E+02	7.0E+01	9.2	2.6E+01	7.6E+00		1.3E-01	3.9E-04	0.49	2.6E-01	8.0E-04	
Barium (Ba)	3.3E-02	1.1E+00	3.3E-01	190	6.1E-03	2.4E-03		6.0E-04	1.8E-06	0.0	9.0E-06	2.3E-07	
Calcium (Ca)	1.3E+00	4.4E+01	1.3E+01	28	2.0E+00	8.8E-01		2.4E-02	6.6E-05	1	2.4E-02	6.6E-05	
Chromium (Cr+3)	0.0E+00	0.0E+00	0.0E+00	61.5	0.0E+00	0.0E+00		0.0E+00	0.0E+00	2.5	0.0E+00	0.0E+00	
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	400	0.0E+00	0.0E+00		0.0E+00	0.0E+00	80	0.0E+00	0.0E+00	
Lanthanum (La)	1.0E+00	3.4E+01	9.8E+00	137	2.8E-01	7.2E-02		1.8E-02	4.8E-05	0.3	2.8E-02	6.8E-05	
Sodium (Na - NaOH)	2.1E+02	7.1E+03	2.1E+03	23	3.1E+02	9.0E+01		4.0E+00	9.8E-03	1.2	3.8E+00	7.9E-03	
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	40	1.8E+02	5.3E+01		4.0E+00	9.8E-03	2	2.0E+00	4.7E-03	
SUM OF FRACTIONS		N/A	N/A	N/A	8.2E+02	1.5E+02		N/A	N/A	N/A	5.4E+00	1.3E-02	
ALLOWABLE RELEASE*		N/A	N/A	N/A	1.0E-03	6.0E-03		N/A	N/A	N/A	1.8E-01	7.8E+01	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-3F. Toxic Chemical Consequences — Unit Releases Double Shell Liquids 10-6 to 10-4 yr-1 Frequency - Corrosives.

TABLE E-3F Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: Double Shell Tanks/Liquids Chemical Inventory: 100% bounding per KEH inventory data
Frequency: 10-6 to 10-4 per year Release Height: Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type		Release Duration			χ/Qs	Release Type	Release Duration				χ/Qs
		Steady State		> 3.5s			3.4E-2 s/m3	Steady State	> 420 s				1.8E-5 s/m3
		Puff		< 3.5s			9.9E-3/m3	Puff	< 420 s				4.9E-3/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide EPPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide EPPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	7.1E+00	2.4E+02	7.0E+01	25	1.0E+01	3.1E+00		1.8E-01	3.3E-04	0.2	1.8E-02	9.8E-05	
Barium (Ba)	9.5E-02	1.1E+00	3.3E-01	344	3.8E-03	9.8E-04		8.3E-04	1.6E-06	138	4.8E-09	1.1E-08	
Calcium (Ca)	1.5E+00	4.4E+01	1.3E+01	84	5.1E-01	2.2E-01		2.4E-02	4.5E-05	22	1.1E-03	2.0E-04	
Chromium (Cr+3)	0.0E+00	0.0E+00	0.0E+00	129	0.0E+00	0.0E+00		0.0E+00	0.0E+00	51.5	0.0E+00	0.0E+00	
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	800	0.0E+00	0.0E+00		0.0E+00	0.0E+00	800	0.0E+00	0.0E+00	
Lanthanum (La)	1.0E+00	3.4E+01	9.8E+00	343	9.9E-02	2.8E-02		1.8E-02	4.5E-05	137	1.4E-04	9.3E-07	
Sodium (Na - NaOH)	2.1E+02	7.1E+03	2.1E+03	58	1.2E+02	3.6E+01		4.0E+00	9.8E-03	23	1.7E-01	4.1E-04	
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	100	7.1E+01	2.1E+01		4.0E+00	9.8E-03	40	1.0E-01	2.4E-04	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	2.1E+02	6.0E+01		N/A	N/A	N/A	2.8E-01	6.8E-04	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	4.9E-03	1.7E-02		N/A	N/A	N/A	3.5E+00	1.5E+00	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-4A. Toxic Chemical Consequences — Unit Releases Double Shell Solids 10-2 to 1 yr-1 Frequency - Toxics.

TABLE E-4A Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: Double Shell Tanks/Solids — Chemical Inventory: Inventory based on WHC-SD-WM-ER-400

Frequency: 10-2 to 10-0 per year — Release Height: Ground Level

Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.5a / < 3.5a		χ/Qs: 3.4E-2 s/m3 / 9.8E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s		χ/Qs: 1.0E-5 s/m3 / 4.6E-6m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	9.8E-06	3.2E-01	9.4E-02	2	1.6E-01	4.7E-02		1.6E-04	4.3E-07	0.3	3.4E-04	9.8E-07	
Arsenic (As)	5.7E+00	1.9E+02	5.6E+01	0.1	1.9E+03	5.6E+02		1.1E-01	2.6E-04	0.01	1.1E+01	2.6E-02	
Beryllium (Be)	1.4E-01	4.6E+00	1.4E+00	0.008	7.6E+02	2.2E+02		2.7E-03	6.5E-06	0.002	1.3E+00	3.2E-03	
Cadmium (Cd)	2.0E+01	6.6E+02	2.0E+02	0.2	4.5E+03	1.3E+03		5.0E-01	1.5E-03	0.005	1.0E+02	2.4E-01	
Cerium (Ce)	2.0E+00	6.0E+01	2.0E+01	70	1.2E+00	3.7E-01		5.0E-02	1.3E-04	2	2.5E-03	6.0E-05	
Cobalt (Co)	9.5E-01	2.2E+01	6.4E+00	0.05	4.4E+02	1.3E+02		1.2E-02	2.9E-05	0.05	2.5E-01	6.8E-04	
Cyanide	4.7E-01	1.6E+01	4.6E+00	5	3.2E+00	9.3E-01		8.6E-03	2.1E-05	5	1.7E-03	4.2E-06	
Mercury (Hg)	1.2E-01	4.1E+00	1.2E+00	0.075	5.4E+01	1.6E+01		2.2E-03	5.4E-06	0.05	4.4E-02	1.1E-04	
Neodymium (Nd)	7.0E+00	2.4E+02	7.0E+01	72	3.3E+00	9.7E-01		1.3E-01	3.2E-04	3.5	3.9E-02	9.0E-05	
Oxalate	2.8E+02	9.4E+03	2.7E+03	4	2.3E+03	6.8E+02		5.3E+00	1.2E-02	1	8.3E+00	1.8E-02	
TOC-Oxalate	7.5E+01	2.5E+03	7.4E+02	3	8.5E+02	2.5E+02		1.4E+00	3.4E-03	2.5	5.7E-01	1.4E-03	
Selenium (Se)	2.4E-01	8.2E+00	2.4E+00	0.2	4.1E+01	1.2E+01		4.8E-03	1.1E-05	0.2	2.2E-02	5.4E-05	
Tellurium (Te)	9.8E-01	3.2E+01	9.3E+00	0.13	2.4E+02	7.1E+01		1.8E-02	4.5E-05	0.1	1.5E-01	4.2E-04	
Thallium (Tl)	1.5E+01	5.1E+02	1.5E+02	0.3	1.7E+03	5.0E+02		2.9E-01	6.9E-04	0.1	2.9E+00	6.9E-03	
Uranium (U)	4.4E+01	1.5E+03	4.4E+02	1	1.5E+03	4.4E+02		8.4E-01	2.0E-03	0.2	4.2E+00	9.9E-03	
Vanadium (V)	4.1E-02	1.4E+00	4.1E-01	1.2	1.2E+00	3.4E-01		7.8E-04	1.8E-06	0.03	2.6E-02	6.2E-05	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	1.4E+04	4.2E+03		N/A	N/A	N/A	1.2E+02	3.0E-01	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	7.0E-05	2.4E-04		N/A	N/A	N/A	8.0E-03	3.4E+00	

* In units of L/s for steady state releases and units of L for puff releases.

** Lower of PEL-TWA and ERPG-1 used for offsite risk guide

Table E-4B. Toxic Chemical Consequences — Unit Releases Double Shell Solids 10-4 to 10-2 yr-1 Frequency - Toxics.

TABLE E-4B Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s: Puff - 1 L)
Tank/Waste Type: Double Shell Tanks/Solids Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-4 to 10-2 per year Release Height: Ground Level
Analyte type: Toxics

A	B	ONSITE (100 Meters) Release Type		Release Duration			XQs	OFFSITE (Site Boundary) Release Type		Release Duration		XQs
				> 3.5s			3.4E-2 s/m3			> 420 s		1.8E-5 s/m3
				< 3.5s			9.8E-3/m3			< 420 s		4.8E-4/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3) Puff	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Antimony (Sb)	9.8E-03	3.3E-01	9.4E-02	40	8.1E-03	2.4E-03		1.8E-04	4.3E-07	2	9.0E-05	2.1E-07
Arsenic (As)	6.7E+00	1.9E+02	5.6E+01	7	2.8E+01	8.1E+00		1.1E-01	2.6E-04	0.1	1.1E+00	2.6E-03
Beryllium (Be)	1.4E-01	4.0E+00	1.4E+00	0.005	1.6E+02	5.6E+01		2.7E-03	9.5E-06	0.005	4.4E-01	1.1E-03
Cadmium (Cd)	2.8E+01	8.0E+02	2.8E+02	1	8.0E+02	2.8E+02		5.0E-01	1.9E-03	0.2	2.8E+00	6.6E-03
Cerium (Ce)	2.0E+00	5.9E+01	2.0E+01	500	1.5E-01	5.2E-02		6.0E-02	1.5E-04	70	7.1E-04	1.7E-03
Cobalt (Co)	8.5E-01	2.2E+01	8.4E+00	0.2	1.1E+02	3.9E+01		1.2E-02	2.9E-05	0.05	2.8E-01	6.9E-04
Cyanide	4.7E-01	1.6E+01	4.6E+00	41	3.9E-01	1.1E-01		8.6E-03	2.1E-05	8	1.2E-03	4.3E-05
Mercury (Hg)	1.2E-01	4.1E+00	1.2E+00	0.1	4.1E+01	1.2E+01		2.2E-03	5.4E-06	0.076	3.0E-02	7.2E-05
Neodymium (Nd)	7.0E+00	2.4E+02	7.0E+01	804	4.7E-01	1.4E-01		1.2E-01	2.9E-04	72	1.6E-03	4.4E-05
Oxalate	2.8E+02	9.4E+03	2.7E+03	20	4.7E+02	1.4E+02		5.2E+00	1.2E-02	4	1.2E+00	3.1E-03
TOC-Oxalate C	7.5E+01	2.6E+03	7.4E+02	15	1.7E+02	5.0E+01		1.4E+00	3.4E-03	3	4.5E-01	1.1E-03
Selenium (Se)	2.4E-01	8.5E+00	2.4E+00	0.4	2.6E+01	8.0E+00		4.6E-03	1.1E-05	0.2	2.5E-02	6.4E-05
Tellurium (Te)	9.3E-01	3.2E+01	9.2E+00	0.3	1.1E+02	3.1E+01		1.8E-02	4.5E-05	0.13	1.4E-01	3.5E-04
Thallium (Tl)	1.5E+01	5.1E+02	1.5E+02	2	2.6E+02	7.4E+01		2.9E-01	6.8E-04	0.3	9.3E-01	2.3E-03
Uranium (U)	4.4E+01	1.5E+03	4.4E+02	10	1.5E+02	4.4E+01		8.4E-01	2.0E-03	1	8.4E-01	2.0E-03
Vanadium (V)	4.1E-02	1.4E+00	4.1E-01	11	1.3E-01	3.7E-02		7.8E-04	1.8E-06	1.2	0.0E-04	1.6E-03
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	2.4E+03	7.1E+02		N/A	N/A	N/A	0.0E+00	1.1E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	4.1E-04	1.4E-03		N/A	N/A	N/A	1.2E-01	5.2E+01

* In units of L/s for steady state releases and units of L for puff releases.

Table E-4C. Toxic Chemical Consequences — Unit Releases Double Shell Solids 10-6 to 10-4 yr-1 Frequency - Toxics.

TABLE E-4C Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: Double Shell Tanks/Solids — Chemical Inventory: — Inventory based on WHC-SD-WM-ER-400

Frequency: 10-6 to 10-4 per year — Release Height: — Ground Level

Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff			Release Duration: > 3.5s / < 3.5s		X/Qs: 3.4E-2 s/m3 / 9.0E-3/m3	Release Type: Steady State / Puff			Release Duration: > 420 s / < 420 s		X/Qs: 1.9E-5 s/m3 / 4.8E-6/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	9.6E-03	3.2E-01	9.4E-02	70	4.6E-03	1.3E-03		1.6E-04	4.5E-07	40	4.0E-06	1.1E-08	
Arsenic (As)	5.7E+00	1.9E+02	5.6E+01	40	4.8E+00	1.4E+00		1.1E-01	2.6E-04	7	1.6E-02	3.7E-05	
Beryllium (Be)	1.4E-01	4.8E+00	1.4E+00	0.1	4.8E+01	1.4E+01		2.7E-03	6.3E-06	0.035	1.1E-01	2.5E-04	
Cadmium (Cd)	2.6E+01	8.8E+02	2.6E+02	10	8.8E+01	2.6E+01		5.0E-01	1.2E-03	1	5.0E-01	1.2E-03	
Cerium (Ce)	2.6E+00	8.8E+01	2.6E+01	700	1.3E-01	3.7E-02		5.0E-02	1.2E-04	500	9.8E-06	2.3E-07	
Cobalt (Co)	0.5E-01	2.2E+01	6.4E+00	8	2.8E+00	8.0E-01		1.2E-02	2.8E-05	0.2	6.5E-02	1.5E-04	
Cyanide	4.7E-01	1.6E+01	4.6E+00	200	8.0E-02	2.3E-02		8.9E-03	2.1E-05	41	2.2E-04	5.1E-07	
Mercury (Hg)	1.2E-01	4.1E+00	1.2E+00	14	2.8E-01	8.0E-02		2.3E-03	5.4E-06	0.1	2.3E-02	5.4E-05	
Neodymium (Nd)	7.0E+00	2.4E+02	7.0E+01	720	3.3E-01	9.7E-02		1.3E-01	3.0E-04	504	2.7E-04	6.3E-07	
Oxalate	2.8E+02	9.4E+03	2.7E+03	40	2.3E+02	6.6E+01		8.3E+00	1.9E-02	28	2.9E-01	6.8E-04	
TOC-Oxalate C	7.5E+01	2.6E+03	7.4E+02	80	5.1E+01	1.5E+01		1.4E+00	3.4E-03	15	9.8E-02	2.3E-04	
Selenium (Se)	2.4E-01	8.2E+00	2.4E+00	2	4.1E+00	1.2E+00		4.6E-03	1.1E-05	0.4	1.1E-02	2.7E-05	
Tellurium (Te)	9.3E-01	3.2E+01	9.2E+00	1.4	2.3E+01	6.6E+00		1.8E-02	4.2E-05	0.3	5.8E-02	1.4E-04	
Thallium (Tl)	1.5E+01	5.1E+02	1.5E+02	20	2.6E+01	7.4E+00		2.8E-01	6.5E-04	2	1.4E-01	3.4E-04	
Uranium (U)	4.4E+01	1.5E+03	4.4E+02	20	7.5E+01	2.2E+01		8.4E-01	2.0E-03	10	8.4E-02	2.0E-04	
Vanadium (V)	4.1E-02	1.4E+00	4.1E-01	40	3.5E-02	1.0E-02		7.8E-04	\1.8E-06	11	7.1E-05	1.7E-07	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	5.6E+02	1.6E+02		N/A	N/A	N/A	1.4E+00	3.3E-03	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	1.8E-03	6.3E-03		N/A	N/A	N/A	7.4E-01	3.1E+02	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-4D. Toxic Chemical Consequences — Unit Releases Double Shell Solids 10-2 to 1 yr-1 Frequency - Corrosives.

TABLE E-4D Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: Double Shell Tanks/Solids — Chemical Inventory: Inventory based on WHC-SD-WM-ER-400

Frequency: 10-2 to 10-0 per year — Release Height: Ground Level

Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)					OFFSITE (Site Boundary)				
		Release Type		Release Duration		X/Qs	Release Type		Release Duration		X/Qs
		Steady State		> 3.5s		3.4E-2 s/m3	Steady State		> 420 s		1.9E-5 s/m3
		Puff		< 3.5s		9.9E-3/m3	Puff		< 420 s		4.5E-8/m3
		C	D	E	F	G	H	I	J	K	L
Analyte	Analyte Concen-tration (g/L)	Steady State Release Consequence (mg/m3)	Puff Release Consequence (mg/m3)	Risk Guide ERPG-1 (mg/m3)	Fraction of Risk Guide Steady State (unitless)	Fraction of Risk Guide Puff (unitless)	Steady State Release Consequence (mg/m3)	Puff Release Consequence (mg/m3)	Risk Guide PEL-TWA (mg/m3)	Fraction of Risk Guide Steady State (unitless)	Fraction of Risk Guide Puff (unitless)
Ammonia (NH3)	6.6E+00	2.2E+02	6.5E+01	0.46	4.9E+02	1.4E+02	1.2E-01	3.0E-04	0.46	2.7E-01	6.5E-04
Barium (Ba)	5.9E+00	2.0E+02	5.8E+01	6.8	3.0E+01	8.6E+00	1.1E-01	2.7E-04	0.5	2.2E-01	5.2E-04
Calcium (Ca)	2.6E+01	8.8E+02	2.6E+02	1	8.8E+02	2.6E+02	4.9E-01	1.2E-03	1	4.9E-01	1.2E-03
Chromium (Cr+3)	1.5E+02	5.1E+03	1.5E+03	2.6	2.0E+03	5.7E+02	2.9E+00	6.8E-03	0.5	5.7E+00	1.4E-02
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	60	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.2	0.0E+00	0.0E+00
Lanthanum (La)	3.0E+01	1.0E+03	3.0E+02	6.9	1.5E+02	4.3E+01	5.7E-01	1.4E-03	6.9	8.2E-02	2.0E-04
Sodium (Na - NaOH)	3.4E+02	1.2E+04	3.4E+03	1.2	9.6E+03	2.8E+03	6.5E+00	1.5E-02	1.2	5.4E+00	1.3E-02
Sod. Hydroxide (NaOH)	2.3E+02	7.8E+03	2.3E+03	2	3.9E+03	1.1E+03	4.4E+00	1.0E-02	2	2.2E+00	5.2E-03
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	1.7E+04	5.0E+03	N/A	N/A	N/A	1.4E+01	3.4E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	5.9E-05	2.0E-04	N/A	N/A	N/A	7.0E-02	2.9E+01

* In units of L/s for steady state releases and units of L for puff releases.

** Lower of PEL-TWA and ERPG-1 used for offsite risk guide

Table E-4E. Toxic Chemical Consequences — Unit Releases Double Shell Solids 10-4 to 10-2 yr-1 Frequency - Corrosives.

TABLE E-4E Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: Double Shell Tanks/Solids Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-4 to 10-2 per year Release Height: Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.5s / < 3.5s		X/Q: 3.4E-2 s/m3 / 9.9E-3/m3		Release Type: Steady State / Puff		Release Duration: > 450 s / < 450 s		X/Q: 1.9E-5 s/m3 / 4.8E-6/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	8.0E+00	2.2E+02	6.5E+01	0.2	2.4E+01	7.1E+00		1.3E+01	3.0E-04	0.49	2.7E+01	6.1E-04	
Barium (Ba)	6.0E+00	2.0E+02	6.3E+01	138	1.5E+00	4.5E-01		1.1E+01	2.7E-04	5.0	1.4E+00	3.1E-05	
Calcium (Ca)	2.4E+01	6.6E+02	2.0E+02	22	4.0E+01	1.2E+01		4.4E+01	1.0E-03	1	4.4E+01	1.0E-03	
Chromium (Cr+3)	1.5E+02	5.1E+03	1.5E+03	51.5	9.9E+01	2.9E+01		2.0E+00	0.4E-03	2.0	1.1E+00	2.5E-03	
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	000	0.0E+00	0.0E+00		0.0E+00	0.0E+00	00	0.0E+00	0.0E+00	
Lanthanum (La)	3.0E+01	1.0E+03	3.0E+02	197	7.4E+00	2.2E+00		0.7E-01	1.4E-03	0.9	0.3E-02	3.0E-04	
Sodium (Na - NaOH)	3.4E+02	1.2E+04	3.4E+03	23	5.0E+02	1.5E+02		0.8E+00	1.8E-02	1.2	0.4E+00	1.5E-02	
Sod. Hydroxide (NaOH)	2.3E+02	7.8E+03	2.3E+03	40	2.0E+02	5.7E+01		4.4E+00	1.0E-02	2	2.2E+00	5.1E-03	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	8.7E+02	2.6E+02		N/A	N/A	N/A	9.0E+00	2.3E-02	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	1.1E-03	3.8E-03		N/A	N/A	N/A	1.0E-01	4.4E+01	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-4F. Toxic Chemical Consequences — Unit Releases Double Shell Solids 10-6 to 10-4 yr-1 Frequency - Corrosives.

TABLE E-4F Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: Double Shell Tanks/Solids Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-6 to 10-4 per year Release Height: Ground Level
Analyte type: Corrosives/Ammonia

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type		Release Duration		X/Qs		Release Type		Release Duration		X/Qs	
		Steady State / Puff		> 3.5s / < 3.5s		3.4E+2 s/m3 / 9.9E-3/m3		Steady State / Puff		> 420 s / < 420 s		1.8E-5 s/m3 / 4.8E-9/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-3 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	6.0E+00	2.2E+02	6.5E+01	23	9.5E+00	2.8E+00		1.3E-01	3.0E-04	0.2	1.4E-02	3.2E-03	
Barium (Ba)	5.9E+00	2.0E+02	5.8E+01	344	5.8E-01	1.7E-01		1.1E-01	2.7E-04	150	8.1E-04	1.8E-06	
Calcium (Ca)	2.8E+01	8.8E+02	2.8E+02	84	1.0E+01	4.0E+00		4.6E-01	1.3E-03	22	2.2E-02	5.8E-05	
Chromium (Cr+3)	1.5E+02	5.1E+03	1.5E+03	129	4.0E+01	1.5E+01		2.5E+00	6.8E-03	51.5	5.1E-02	1.2E-04	
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	800	0.0E+00	0.0E+00		0.0E+00	0.0E+00	600	0.0E+00	0.0E+00	
Lanthanum (La)	3.0E+01	1.0E+03	3.0E+02	343	3.0E+00	8.7E-01		5.7E-01	1.4E-03	157	4.3E-03	9.8E-06	
Sodium (Na - NaOH)	3.4E+02	1.2E+04	3.4E+03	58	2.0E+02	6.3E+01		6.5E+00	1.8E-02	23	2.8E-01	6.7E-04	
Sod. Hydroxide (NaOH)	2.3E+02	7.8E+03	2.3E+03	100	7.8E+01	2.3E+01		4.4E+00	1.0E-02	40	1.1E-01	2.5E-04	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	3.5E+02	1.0E+02		N/A	N/A	N/A	4.1E-01	1.3E-03	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	2.9E-03	9.9E-03		N/A	N/A	N/A	2.1E+00	8.7E+02	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-5A. Toxic Chemical Consequences — Unit Releases - Gases
10-2 to 1 yr-1 Frequency.

TABLE E-5A Toxic Chemical Consequences - Unit Releases (Steady State - 1 m3/s, Puff - 1 m3) Chemical Inventory: Maximum C-103 Headspace data for organics; Slurry gas concentrations assumed for NH3 and nitrous oxide

Tank/Waste Type: Gases Release Height: Ground Level

Frequency: 10-2 to 10 0 per year

A	B	ONSITE (100 Meters) Release Type: Steady State / Puff; Release Duration: >3.5 s / <3.5 s; X/Qs: 3.4E-2 s/m3 / 9.9E-3/m3					OFFSITE (Site Boundary) Release Type: Steady State / Puff; Release Duration: >420 s / <420 s; X/Qs: 1.9E-5 s/m3 / 4.6E-6/m3				
Analyte	Head-space Conc. (mg/m3)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk** Guide PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
TOXICS - CENTRAL NERVOUS SYSTEM											
Benzene	1.32	4.3E-02	1.3E-02	76	5.6E-04	1.7E-04	2.5E-05	5.9E-06	3	8.4E-06	2.0E-06
Butanol	184.13	5.4E+00	1.6E+00	75	7.2E-02	2.1E-02	3.1E-03	7.4E-04	75	4.2E-05	9.8E-06
Dodecane	296	9.7E+00	2.9E+00	37	2.6E-01	7.8E-02	5.6E-03	1.3E-03	37	1.5E-04	3.6E-07
2-Hexanone	2.66	8.6E-02	2.6E-02	50	1.8E-03	5.3E-04	5.1E-05	1.2E-07	20	2.5E-06	6.0E-09
Nitrous oxide^	112000	3.7E+03	1.1E+03	270	1.4E+01	4.1E+00	2.1E+00	5.0E-03	90	2.4E-02	5.6E-05
Tridecane	366	1.3E+01	3.8E+00	37	3.4E-01	1.0E-01	7.4E-03	1.7E-05	37	2.0E-04	4.7E-07
SUM OF FRACTIONS	NA	NA	NA	NA	1.4E+01	4.3E+00	NA	NA	NA	2.4E-02	5.7E-06
ALLOWABLE RELEASE +	NA	NA	NA	NA			NA	NA	NA		
TOXICS - SYSTEMIC POISONS											
Acetonitrile	21.81	7.2E-01	2.1E-01	3	2.4E-01	7.1E-02	4.1E-04	9.8E-07	3	1.4E-04	3.3E-07
Propane nitrile	10.47	3.4E-01	1.0E-01	3	1.1E-01	3.4E-02	2.0E-04	4.7E-07	3	6.6E-05	1.6E-07
SUM OF FRACTIONS	NA	NA	NA	NA	3.5E-01	1.1E-01	NA	NA	NA	2.0E-04	4.8E-07
ALLOWABLE RELEASE +	NA	NA	NA	NA			NA	NA	NA		
CORROSIVES AND IRRITANTS											
Ammonia^	39800	1.3E+03	3.9E+02	17	7.7E+01	2.3E+01	7.6E-01	1.8E-03	17	4.4E-02	1.1E-04
1,3 Butadiene	0.19	6.2E-03	1.9E-03	22	2.8E-04	8.5E-05	3.6E-06	8.5E-09	22	1.6E-07	3.9E-10
Methylene chloride	21.76	7.2E-01	2.1E-01	700	1.0E-03	3.0E-04	4.1E-04	9.8E-07	174	2.4E-06	5.6E-09
Tributyl phosphate	11.6	3.8E-01	1.1E-01	3	1.3E-01	3.8E-02	2.2E-04	5.2E-07	2.5	8.8E-05	2.1E-07
SUM OF FRACTIONS	NA	NA	NA	NA	7.7E+01	2.3E+01	NA	NA	NA	4.5E-02	1.1E-04
ALLOWABLE RELEASE +	NA	NA	NA	NA			NA	NA	NA		

^ D.D. Mahlum et al., "Toxicologic Evaluation of Analytes from Tank 241-C-103," PNL-10189, November 1994.

+ Allowable releases are in units of m3/s for steady state releases and units of m3 for puff releases.

** Lower of the PEL-TWA and ERPG-1 used for the offsite risk guide

Table E-5B. Toxic Chemical Consequences — Unit Releases Gases 10-4 to 10-2 yr-1 Frequency

TABLE E-5B Toxic Chemical Consequences - Unit Releases (Steady State - 1 m3/s, Puff - 1 m3)

Chemical Inventory: Maximum C-103 Headspace data for organics. Slurry gas concentrations assumed for NH3 and nitrous oxide

Tank/Waste Type: Gases

Frequency: 10-4 to 10-2 per year

Release Height: Ground Level

A	B	ONSITE (100 Meters)							OFFSITE (Site Boundary)						
				Release Duration >3.5 s <3.5 s			χ/Qs 3.4E-2 s/m3 9.8E-3/m3		Release Type Steady State Puff		Release Duration >420 s <420 s		χ/Qs 1.9E-5 s/m3 4.5E-6/m3		
Analyte	Headspace Conc. (mg/m3)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E TWA Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J TWA Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)				
TOXICS - CENTRAL NERVOUS SYSTEM															
Benzene	1.32	4.3E-02	1.3E-02	1565	2.8E-05	8.3E-06	2.5E-05	8.9E-06	78	3.2E-07	7.8E-10				
2-Butanol	164.13	5.4E+00	1.0E+00	750	7.2E-03	2.1E-03	3.1E-03	7.4E-06	75	4.2E-05	9.8E-08				
Dodecane	286	9.7E+00	2.0E+00	1450	6.7E-03	2.0E-03	5.8E-03	1.3E-05	37	1.8E-04	3.8E-07				
2-Heptanone	2.08	6.8E-02	2.0E-02	500	1.4E-04	5.3E-05	6.1E-05	1.2E-07	80	1.0E-06	2.4E-09				
Nitrous oxide	112000	3.7E+03	1.1E+03	10000	2.0E-01	6.1E-02	2.1E+00	6.0E-03	270	7.8E-03	1.8E-05				
Tridecane	388	1.3E+01	3.0E+00	1450	8.8E-03	2.6E-03	7.4E-03	1.7E-05	37	2.0E-04	4.7E-07				
SUM OF FRACTIONS	NA	NA	NA	NA	2.3E-01	6.0E-02	NA	NA	NA	8.5E-03	2.0E-05				
ALLOWABLE RELEASE	NA	NA	NA	NA			NA	NA	NA						
TOXICS - SYSTEMIC POISONS															
Acetonitrile	21.01	7.2E-01	2.1E-01	20	3.6E-02	1.1E-02	4.1E-04	9.8E-07	3	1.4E-04	3.3E-07				
Propane nitrile	10.47	3.4E-01	1.0E-01	20	1.7E-02	5.1E-03	2.0E-04	4.7E-07	3	6.8E-05	1.6E-07				
SUM OF FRACTIONS	NA	NA	NA	NA	5.3E-02	1.6E-02	NA	NA	NA	2.0E-04	4.8E-07				
ALLOWABLE RELEASE	NA	NA	NA	NA			NA	NA	NA						
CORROSIVES AND IRRITANTS															
Ammonia	39600	1.3E+03	3.8E+02	140	9.3E+00	2.8E+00	7.6E-01	1.8E-03	17	4.4E-02	1.1E-04				
1,3 Butadiene	0.18	6.2E-03	1.9E-03	110	5.7E-05	1.7E-05	3.0E-06	6.5E-09	22	1.0E-07	3.9E-10				
Methylene chloride	21.76	7.2E-01	2.1E-01	3480	2.1E-04	6.1E-05	4.1E-04	9.8E-07	700	5.9E-07	1.4E-09				
Tributyl phosphate	11.6	3.8E-01	1.1E-01	15	2.5E-02	7.6E-03	2.2E-04	5.2E-07	3	7.3E-06	1.7E-07				
SUM OF FRACTIONS	NA	NA	NA	NA	9.4E+00	2.8E+00	NA	NA	NA	4.5E-02	1.1E-04				
ALLOWABLE RELEASE	NA	NA	NA	NA			NA	NA	NA						

D.D. Mahlum et al., "Toxicologic Evaluation of Analytes from Tank 241-C-103," PNL-10169, November 1994.

+ Allowable releases are in units of m3/s for steady state releases and units of m3 for puff releases.

Table E-5C. Toxic Chemical Consequences — Unit Releases Gases Worst Case with Slurry Gases 10-6 to 10-4 yr-1 Frequency.

TABLE E-5C Toxic Chemical Consequences - Unit Releases (Steady State - 1 m3/s, Puff - 1 m3)

Tank/Waste Type: Gases

Frequency: 10-6 to 10-4 per year

Chemical Inventory: Maximum C-103 Headspace data for organics. Slurry gas concnetrations assumed for NH3 and N2O

Release Height: Ground Level

A	B	ONSITE (100 Meters)					OFFSITE (Site Boundary)				
		Release Type: Steady State / Puff		Release Duration: >3.5 s / <3.5 s		X/Qs: 3.4E-2 s/m3 / 9.9E-3/m3	Release Type: Steady State / Puff		Release Duration: >420 s / <420 s		X/Qs: 1.9E-5 s/m3 / 4.8E-8/m3
Analyte	Head-space Conc. (mg/m3)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
TOXICS - CENTRAL NERVOUS SYSTEM											
Benzene	1.32	4.3E-02	1.3E-02	3130	1.4E-05	4.1E-06	2.6E-05	6.6E-06	1995	1.6E-06	3.6E-11
Butanol	164.13	5.4E+00	1.6E+00	7500	7.2E-04	2.1E-04	3.1E-03	7.4E-06	750	4.2E-06	9.6E-09
Dodecane	296	9.7E+00	2.9E+00	7330	1.3E-03	4.0E-04	5.6E-03	1.3E-05	1450	3.9E-06	9.2E-09
2-Hexanone	2.68	8.6E-02	2.6E-02	5000	1.8E-05	5.3E-06	5.1E-05	1.2E-07	500	1.0E-07	2.4E-10
Nitrous oxide	112000	3.7E+03	1.1E+03	36000	1.0E-01	3.0E-02	2.1E+00	5.0E-03	15000	1.2E-04	2.8E-07
Tridecane	366	1.3E+01	3.9E+00	7330	1.7E-03	5.2E-04	7.4E-03	1.7E-05	1450	5.1E-06	1.2E-08
SUM OF FRACTIONS	NA	NA	NA	NA	1.1E-01	3.2E-02	NA	NA	NA	1.3E-04	3.1E-07
ALLOWABLE RELEASE+	NA	NA	NA	NA			NA	NA	NA		
TOXICS - SYSTEMIC POISONS											
Acetonitrile	21.81	7.2E-01	2.1E-01	60	1.2E-02	3.6E-03	4.1E-04	9.8E-07	20	2.1E-05	4.9E-08
Propane nitrile	10.47	3.4E-01	1.0E-01	60	5.7E-03	1.7E-03	2.0E-04	4.7E-07	20	9.6E-06	2.4E-08
SUM OF FRACTIONS	NA	NA	NA	NA	1.8E-02	5.3E-03	NA	NA	NA	3.1E-05	7.3E-08
ALLOWABLE RELEASE+	NA	NA	NA	NA			NA	NA	NA		
CORROSIVES AND IRRITANTS											
Ammonia	36600	1.3E+03	3.9E+02	660	1.9E+00	5.7E-01	7.6E-01	1.8E-03	140	5.4E-03	1.3E-05
1,3 Butadiene	0.19	8.2E-03	1.9E-03	11000	5.7E-07	1.7E-07	3.6E-08	8.5E-08	110	3.3E-08	7.8E-11
Methylene chloride	21.76	7.2E-01	2.1E-01	17400	4.1E-05	1.2E-05	4.1E-04	9.8E-07	3480	1.2E-07	2.8E-10
Tributyl phosphate	11.6	3.6E-01	1.1E-01	50	7.6E-03	2.3E-03	2.2E-04	5.2E-07	15	1.6E-05	3.8E-08
SUM OF FRACTIONS	NA	NA	NA	NA	≠ 1.9E+00	≠ 5.6E-01	NA	NA	NA	≠ 5.4E-03	≠ 1.3E-05
ALLOWABLE RELEASE+	NA	NA	NA	NA			NA	NA	NA		

D.D. Mahlum et al., "Toxicologic Evaluation of Analytes from Tank 241-C-103," PNL-10189, November 1994.

+ Allowable releases are in units of m3/s for steady state releases and units of m3 for puff releases.

Table E-5D. Toxic Chemical Consequences — Unit Releases - Gases Max Sample Data 10-2 to 1 yr-1 Frequency.

TABLE E-5D Toxic Chemical Consequences - Unit Releases (Steady State - 1 m3/s, Puff - 1 m3)

Tank/Waste Type: Gases

Frequency: 10-2 to 10-0 per year

Chemical Inventory:

Maximum C-103 Headspace data for organics
Max steady sample gas concentrations assumed for NH3 and N2O

Release Height: Ground Level

A	B	ONSITE (100 Meters)						OFFSITE (at the boundary)					
		C	D	E	F	G		H	I	J	K	L	
Analyte	Headspace Conc. (mg/m3)	Release Type Steady State Release Consequence (mg/m3)	Puff Release Consequence (mg/m3)	Risk Guide EPPG-1 (mg/m3)	Release Duration >3.5 s Fraction of Risk Guide Steady State (unitless)	Release Duration <3.5 s Fraction of Risk Guide Puff (unitless)	X/Q 3.4E-2 s/m3 9.9E-3/m3	Release Type Steady State Release Consequence (mg/m3)	Puff Release Consequence (mg/m3)	Risk** Guide PEL-TWA (mg/m3)	Fraction of Risk Guide Steady State (unitless)	Fraction of Risk Guide Puff (unitless)	X/Q 1.8E-5 s/m3 4.8E-4m3
TOXICS - CENTRAL NERVOUS SYSTEM													
Acetone	1.3E+4	1.8E+04	1.8E+04	70	1.1E+01	1.1E+01		1.6E+03	3.1E+04	3	1.5E+04	1.0E+04	
Ethanol	1.6E+4	1.6E+04	1.6E+04	76	7.2E+02	2.1E+02		3.1E+03	7.7E+04	75	4.2E+03	1.0E+03	
Isobutane	2.6E+4	2.3E+04	2.3E+04	57	2.5E+01	7.7E+02		1.0E+03	1.3E+04	57	1.1E+04	3.1E+07	
2-Hexanone	2.6E+1	2.6E+02	2.6E+02	69	1.9E+00	5.8E+04		8.1E+03	1.1E+05	20	2.3E+03	0.0E+00	
Methyl oxide*	2990	7.7E+01	2.3E+01	270	2.8E+01	1.1E+00		2.4E+02	1.1E+04	69	1.8E+04	1.1E+06	
Hexane	3983	1.3E+01	3.1E+00	57	3.2E+01	1.1E+01		7.4E+03	1.7E+05	57	1.1E+01	4.7E+07	
SUM OF FRACTIONS	NA	NA	NA	NA	8.7E+01	2.1E+01		NA	NA	NA	1.1E+01	2.1E+06	
ALLOWABLE RELEASE†	NA	NA	NA	NA				NA	NA	NA			
TOXICS - SYSTEMIC POISONS													
Acetonitrile	31.01	7.2E+01	2.1E+01	3	2.6E+01	7.1E+02		4.1E+04	1.5E+04	3	1.4E+04	3.1E+07	
Propane nitrile	10.47	3.4E+01	1.0E+01	3	1.1E+01	3.4E+02		2.0E+04	4.7E+07	3	1.0E+03	1.1E+07	
SUM OF FRACTIONS	NA	NA	NA	NA	3.7E+01	1.1E+01		NA	NA	NA	2.5E+01	4.2E+07	
ALLOWABLE RELEASE†	NA	NA	NA	NA				NA	NA	NA			
CORROSIVES AND IRRITANTS													
Ammonia*	1500	1.5E+01	1.5E+01	17	2.1E+00	7.4E+01		2.8E+02	3.1E+05	17	1.8E+04	3.1E+06	
1,3 Butadiene	0.19	6.2E+03	1.9E+03	22	2.6E+04	8.0E+05		3.8E+06	1.8E+08	22	1.6E+07	3.1E+10	
Vinylidene chloride	21.76	7.2E+01	2.1E+01	700	1.0E+03	3.0E+04		4.1E+04	1.8E+07	174	2.4E+03	6.1E+09	
Ethodyl phosphate	11.6	3.8E+01	1.1E+01	3	1.3E+01	3.8E+02		2.2E+04	0.8E+07	2.6	1.1E+03	2.1E+07	
SUM OF FRACTIONS	NA	NA	NA	NA	2.8E+00	7.8E+01		NA	NA	NA	1.5E+03	3.7E+06	
ALLOWABLE RELEASE†	NA	NA	NA	NA				NA	NA	NA			

D.D. Mishima et al., "Toxicologic Evaluation of Analytes from Tank 241-C-103," PNL-10169, November 1994.

+ Allowable releases are in units of m3/s for steady state releases and units of m3 for puff releases.

** Lower of the PEL-TWA and EPPG-1 used for the offsite risk guide.

Table E-5E. Toxic Chemical Consequences — Unit Releases Gases Max Sample Data 10-4 to 10-2 yr-1 Frequency.

TABLE E-5E Toxic Chemical Consequences - Unit Release (Steady State - 1 m3/s, Puff - 1 m3)

Tank/Waste Type: Gases

Frequency: 10-4 to 10-2 per year

Chemical Inventory:

Release Height: Ground Level

Maximum C-103 Headspace data for organics maximum sample gas concentrations assumed for NH3 and nitrous oxide

A	B	ONSITE (100 Meters)						OFFSITE (895 Boundary)					
		Release Type Steady State Puff		Release Duration >3.5 s <3.5 s			X/Q's 3.4E-2 s/m3 9.9E-3s/m3	Release Type Steady State Puff		Release Duration >420 s <420 s			X/Q's 1.0E-3 s/m3 4.0E-4s/m3
Analyte	Head-space Conc. (mg/m3)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
TOXICS - CENTRAL NERVOUS SYSTEM													
Acetone	1.32	7.4E-06	1.3E-05	19000	3.9E-10	6.8E-10		2.5E-08	8.8E-08	70	3.6E-07	6.2E-07	7.4E-10
Phenol	164.13	9.4E+00	1.6E+00	760	1.2E-02	2.1E-03		3.1E-04	7.2E-05	76	4.1E-06	9.5E-07	1.8E-08
Dodecane	266	8.7E+00	2.1E+00	1400	6.2E-03	2.0E-03		8.1E-05	1.3E-05	57	1.4E-04	3.5E-05	3.1E-07
2-Hexanone	2.66	2.4E-02	2.4E-02	600	1.8E-05	6.8E-05		6.1E-07	1.9E-07	60	1.0E-06	2.4E-06	2.4E-09
Nitrous oxide	2940	7.7E+01	2.3E+01	18000	1.3E-03	1.3E-03		4.7E-02	1.1E-02	270	1.8E-04	1.8E-04	1.8E-07
Tridecane	300	1.3E+01	3.1E+00	1400	6.1E-03	2.2E-03		7.4E-05	1.7E-05	57	2.1E-04	4.7E-05	4.7E-07
SUM OF FRACTIONS	NA	NA	NA	NA	2.7E-02	6.1E-03		NA	NA	NA	1.1E-04	1.3E-04	1.3E-06
ALLOWABLE RELEASE+	NA	NA	NA	NA				NA	NA	NA			
TOXICS - SYSTEMIC POISONS													
Acetonitrile	21.81	7.2E-01	2.1E-01	20	3.6E-02	1.1E-02		4.1E-04	9.8E-05	3	1.2E-04	3.5E-07	
Propene nitrile	10.17	3.4E-01	1.0E-01	20	1.7E-02	5.1E-03		2.0E-04	4.7E-05	3	6.0E-05	1.8E-07	
SUM OF FRACTIONS	NA	NA	NA	NA	5.3E-02	1.6E-02		NA	NA	NA	2.0E-04	4.1E-07	
ALLOWABLE RELEASE+	NA	NA	NA	NA				NA	NA	NA			
CORROSIVES AND IRRITANTS													
Ammonia	76.00	4.3E+01	1.3E+01	140	3.1E-01	9.1E-02		2.3E-02	5.6E-03	17	1.0E-03	3.1E-03	
1,3 Butadiene	0.19	6.8E-03	1.8E-03	110	6.2E-05	1.7E-05		3.1E-06	1.0E-06	22	1.4E-07	3.6E-10	
Methylene chloride	21.76	7.2E-01	2.1E-01	3400	2.1E-04	6.1E-05		4.1E-04	9.8E-07	700	6.0E-07	1.4E-09	
Triethyl phosphate	11.6	3.8E-01	1.1E-01	15	2.8E-02	7.8E-03		2.2E-04	5.2E-07	3	7.3E-05	1.7E-07	
SUM OF FRACTIONS	NA	NA	NA	NA	3.4E-01	1.0E-02		NA	NA	NA	1.5E-03	3.3E-06	
ALLOWABLE RELEASE+	NA	NA	NA	NA				NA	NA	NA			

D.D. Mahlum et al., "Toxicologic Evaluation of Analytes from Tank 241-C-103," PNL-10189, November 1994.

+ Allowable releases are in units of m3/s for steady state releases and units of m3 for puff releases.

Table E-5F. Toxic Chemical Consequences — Unit Releases Gases Max Sample Data 10-6 to 10-4 yr-1 Frequency.

TABLE E-5F Toxic Chemical Consequences - Unit Releases (Steady State - 1 m3/s, Puff - 1 m3)

Tank/Waste Type: Gases

Frequency: 10-6 to 10-4 per year

Chemical Inventory: Maximum C-103 Headspace data for organics
Max steady sample gas concentrations assumed for NH3 and N2O

Release Height: Ground Level

A	B	ONSITE (100 Meters)					OFFSITE (Site Boundary)				
		Release Type: Steady State / Puff		Release Duration: >3.5 s / <3.5 s		X/Qs: 3.4E-2 s/m3 / 9.9E-3/m3	Release Type: Steady State / Puff		Release Duration: >420 s / <420 s		X/Qs: 1.9E-5 s/m3 / 4.6E-8/m3
Analyte	Head-space Conc. (mg/m3)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
TOXICS - CENTRAL NERVOUS SYSTEM											
Benzene	1.32	4.3E-02	1.3E-02	3130	1.4E-05	4.1E-06	2.8E-05	5.8E-06	1555	1.8E-05	3.8E-11
Butanol	164.13	5.4E+00	1.6E+00	7600	7.2E-04	2.1E-04	3.1E-03	7.4E-05	780	4.2E-06	9.8E-09
Dodecane	298	9.7E+00	2.9E+00	7200	1.3E-03	4.0E-04	5.6E-03	1.3E-05	1400	3.9E-06	9.1E-09
2-Hexanone	2.68	8.8E-02	2.6E-02	5000	1.8E-05	5.3E-06	5.1E-05	1.2E-07	600	1.8E-07	2.4E-10
Nitrous oxide	2340	7.7E+01	2.3E+01	30000	2.1E-03	6.4E-04	4.4E-02	1.1E-04	18000	2.9E-06	6.8E-09
Tridecane	398	1.3E+01	3.9E+00	7330	1.7E-03	5.2E-04	7.4E-03	1.7E-05	1480	5.1E-06	1.2E-08
SUM OF FRACTIONS	NA	NA	NA	NA	6.0E-03	1.8E-03	NA	NA	NA	1.6E-05	3.7E-08
ALLOWABLE RELEASE+	NA	NA	NA	NA			NA	NA	NA		
TOXICS - SYSTEMIC POISONS											
Acetonitrile	21.61	7.2E-01	2.1E-01	60	1.2E-02	3.6E-03	4.1E-04	9.6E-07	20	2.1E-05	4.9E-08
Propane nitrile	10.47	3.4E-01	1.0E-01	60	5.7E-03	1.7E-03	2.0E-04	4.7E-07	20	9.9E-06	2.4E-09
SUM OF FRACTIONS	NA	NA	NA	NA	1.8E-02	5.3E-03	NA	NA	NA	3.1E-05	7.2E-08
ALLOWABLE RELEASE+	NA	NA	NA	NA			NA	NA	NA		
CORROSIVES AND IRRITANTS											
Ammonia	1380	4.3E+01	1.3E+01	680	6.3E-02	1.9E-02	2.5E-02	5.8E-05	140	1.8E-04	4.2E-07
1,3 Butadiene	0.19	6.2E-03	1.9E-03	11000	5.7E-07	1.7E-07	3.6E-06	8.5E-09	110	3.3E-08	7.8E-11
Methylene chloride	21.76	7.2E-01	2.1E-01	17400	4.1E-05	1.2E-05	4.1E-04	9.6E-07	3480	1.2E-07	2.8E-10
Tributyl phosphate	11.6	3.8E-01	1.1E-01	50	7.6E-03	2.3E-03	2.2E-04	5.2E-07	15	1.5E-05	3.5E-08
SUM OF FRACTIONS	NA	NA	NA	NA	7.1E-02	+ 2.1E-02	NA	NA	NA	+ 1.9E-04	+ 4.5E-07
ALLOWABLE RELEASE+	NA	NA	NA	NA			NA	NA	NA		

D.D. Mahlum et al., "Toxicologic Evaluation of Analytes from Tank 241-C-103," PNL-10189, November 1994.

+ Allowable releases are in units of m3/s for steady state releases and units of m3 for puff releases.

Table E-6A. Toxic Chemical Consequences — Unit Releases DST Flammable Gas Watch List Tanks 10-2 to 1 yr-1 Frequency - Toxics.

TABLE E-6A Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: DST Flammable Gas Watch Tanks Composite — Chemical Inventory: — Inventory based on WHC-SD-WM-ER-400
Frequency: 10-2 to 10-0 per year — Release Height: — Ground Level
Analyte type: Toxics

A	B	ONSITE (100 Meters)							OFFSITE (Site Boundary)					
		Release Type: Steady State Puff			Release Duration: > 3.5s / < 3.5s		X/Qs: 3.4E-2 s/m3 / 9.8E-3/m3		Release Type: Steady State Puff		Release Duration: > 420 s / < 420 s			X/Qs: 1.9E-5 s/m3 / 4.8E-6/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)			
Antimony (Sb)	6.4E-03	2.2E-01	6.3E-02	2	1.1E-01	3.2E-02	1.2E-04	2.9E-07	0.5	2.4E-04	5.8E-07			
Arsenic (As)	3.5E+00	1.1E+02	3.3E+01	0.1	1.1E+00	3.3E+00	6.5E-02	1.5E-04	0.01	6.5E+00	1.5E-02			
Beryllium (Be)	1.4E-01	4.5E+00	1.4E+00	0.005	7.9E+02	2.3E+02	2.7E-03	6.3E-06	0.0002	1.3E+01	3.1E-03			
Cadmium (Cd)	1.6E-01	5.4E+00	1.6E+00	0.2	2.7E+01	7.8E+00	3.0E-03	7.1E-06	0.005	0.6E-01	1.4E-03			
Cerium (Ce)	2.6E+00	8.9E+01	2.6E+01	70	1.3E+00	3.7E-01	5.0E-02	1.2E-04	2	2.5E-02	5.8E-05			
Cobalt (Co)	8.5E-01	2.2E+01	6.4E+00	0.05	4.4E+02	1.3E+02	1.2E-02	2.9E-05	0.05	2.5E-01	5.8E-04			
Cyanide	4.7E-01	1.6E+01	4.6E+00	5	3.2E+00	0.9E-01	8.6E-03	2.1E-05	5	1.6E-03	4.3E-06			
Mercury (Hg)	3.2E-02	1.1E+00	3.2E-01	0.075	1.6E+01	4.2E+00	6.1E-04	1.4E-06	0.05	1.2E-02	2.8E-05			
Neodymium (Nd)	7.0E+00	2.4E+02	7.0E+01	72	3.3E+00	9.7E-01	1.3E-01	3.2E-04	3.5	3.8E-03	9.0E-05			
Oxalate	1.2E+02	4.0E+03	1.2E+03	4	9.6E+02	2.8E+02	2.2E+00	5.5E-03	1	2.2E+00	5.2E-03			
TOC-Oxalate C	3.2E+01	1.1E+03	3.2E+02	3	3.6E+02	1.1E+02	0.1E-01	1.4E-03	2.5	2.4E-01	5.6E-04			
Selenium (Se)	2.4E-01	8.2E+00	2.4E+00	0.2	4.1E+01	1.2E+01	4.6E-03	1.1E-05	0.2	2.2E-02	5.4E-05			
Tellurium (Te)	9.3E-01	3.2E+01	9.2E+00	0.13	2.4E+02	7.1E+01	1.8E-02	4.2E-05	0.1	1.8E-01	4.2E-04			
Thallium (Tl)	1.5E+01	5.1E+02	1.5E+02	0.3	1.7E+03	5.0E+02	2.9E-01	6.8E-04	0.1	2.9E+00	6.8E-03			
Uranium (U)	3.9E-01	1.3E+01	3.8E+00	1	1.3E+01	3.9E+00	7.3E-03	1.7E-05	0.2	3.7E-02	0.7E-05			
Vanadium (V)	4.1E-02	1.4E+00	4.1E-01	1.2	1.2E+00	3.4E-01	7.8E-04	1.8E-06	0.03	2.6E-02	0.3E-05			
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	5.8E+03	1.7E+03	N/A	N/A	N/A	1.4E+01	3.4E-02			
ALLOWABLE RELEASE**	N/A	N/A	N/A	N/A	1.7E-04	5.9E-04	N/A	N/A	N/A	7.1E-02	3.0E+01			

* In units of L/s for steady state releases and units of L for puff releases.
** Lower of PEL-TWA and ERPG-1 used for offsite risk guide

Table E-6B. Toxic Chemical Consequences — Unit Releases DST Flammable Gas Watch List Tanks 10-4 to 10-2 yr-1 Frequency - Toxics.

TABLE E-6B Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: DST Flammable Gas Watch List Composite Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-4 to 10-2 per year Release Height: Ground Level
Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)				
		Release Type	Release Duration			X/Qs	Release Type	Release Duration			X/Qs
		Steady State Puff	> 3.5s < 3.5s			3.4E-2 s/m3 9.9E-3/m3	Steady State Puff	> 420 s < 420 s			1.8E-5 s/m3 4.5E-4/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide EPPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide EPPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Antimony (Sb)	6.4E-03	2.2E-01	6.3E-02	40	5.4E-03	1.8E-03	1.5E-04	2.5E-07	2	8.1E-05	1.4E-07
Arsenic (As)	3.5E+00	1.1E+02	3.3E+01	7	1.6E+01	4.7E+00	8.5E-02	1.5E-04	0.1	8.5E-01	1.5E-03
Beryllium (Be)	1.4E-01	4.5E+00	1.4E+00	0.035	1.8E+02	5.3E+01	2.7E-03	4.5E-06	0.005	4.4E-01	1.1E-03
Cadmium (Cd)	1.0E-01	5.4E+00	1.5E+00	1	5.4E+00	1.6E+00	2.5E-03	7.1E-06	0.2	1.8E-02	2.6E-05
Cerium (Ce)	2.8E+00	8.9E+01	2.6E+01	500	1.5E-01	5.2E-02	5.0E-02	1.5E-04	70	7.1E-04	1.7E-03
Cobalt (Co)	8.8E-01	2.2E+01	6.4E+00	0.2	1.1E+02	3.2E+01	1.5E-02	2.5E-05	0.05	2.5E-01	5.8E-04
Cyanide	4.7E-01	1.5E+01	4.5E+00	41	3.8E-01	1.1E-01	8.5E-03	2.1E-05	5	1.6E-03	4.3E-05
Mercury (Hg)	3.2E-02	1.1E+00	3.3E-01	0.1	1.1E+01	3.3E+00	8.1E-04	< 1.4E-06	0.075	8.1E-03	1.5E-05
Neodymium (Nd)	7.0E+00	2.4E+02	7.0E+01	804	4.7E-01	1.4E-01	1.3E-01	3.3E-04	72	1.8E-03	4.4E-03
Oxalate	1.2E+02	4.0E+03	1.2E+03	20	2.0E+02	5.8E+01	2.2E+00	5.5E-03	4	5.5E-01	1.3E-03
TOC (Oxalate C)	3.2E+01	1.1E+03	3.2E+02	16	7.2E+01	2.1E+01	6.1E-01	1.4E-03	3	2.5E-01	4.8E-04
Rubidium (Rb)	2.4E-01	8.3E+00	2.4E+00	0.4	2.0E+01	5.9E+00	4.6E-03	1.1E-05	0.2	2.3E-02	5.4E-05
Tellurium (Te)	8.3E-01	3.2E+01	9.5E+00	0.3	1.1E+02	3.1E+01	1.6E-02	4.2E-05	0.13	1.4E-01	3.2E-04
Thallium (Tl)	1.5E+01	5.1E+02	1.5E+02	2	2.6E+02	7.4E+01	2.9E-01	6.8E-04	0.3	8.5E-01	2.2E-03
Uranium (U)	3.8E-01	1.3E+01	3.6E+00	10	1.3E+00	3.9E-01	7.5E-03	1.7E-05	1	7.3E-03	1.7E-05
Vanadium (V)	4.1E-02	1.4E+00	4.1E-01	11	1.3E-01	3.7E-02	7.8E-04	1.8E-06	1.2	6.0E-04	1.3E-06
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	9.3E+02	2.6E+02	N/A	N/A	N/A	3.3E+00	7.3E-03
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	1.0E-03	3.8E-03	N/A	N/A	N/A	3.1E-01	1.3E+02

* In units of L/s for steady state releases and units of L for puff releases.

Table E-6C. Toxic Chemical Consequences — Unit Releases DST Flammable Gas Watchlist Tanks 10-6 to 10-4 yr-1 Frequency - Toxics.

TABLE E-6C — Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: DST Flammable Gas Watch List Composite — Chemical Inventory: 100% bounding per KEH Inventory data
Frequency: 10-6 to 10-4 per year — Release Height: Ground Level
Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFF-SITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.6s / < 3.6s		X/Qs: 3.4E-2 s/m3 / 9.0E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s		X/Qs: 1.9E-5 s/m3 / 4.8E-6/m3	
Analyte	Analyte Concentration (ug/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	0.4E-03	2.3E-01	6.3E-02	70	3.1E-03	6.1E-04		1.5E-04	3.9E-07	40	3.8E-03	7.2E-09	
Arsenic (As)	3.3E+00	1.1E+02	3.3E+01	40	2.8E+00	5.5E-01		8.5E-02	1.5E-04	7	0.15E-03	2.1E-05	
Beryllium (Be)	1.4E-01	4.8E+00	1.4E+00	0.1	4.8E+01	1.4E+01		2.7E-03	6.5E-06	0.008	1.1E-01	2.5E-04	
Cadmium (Cd)	1.0E-01	5.4E+00	1.6E+00	10	5.4E-01	1.3E-01		3.0E-03	7.1E-06	1	3.0E-03	7.1E-06	
Cerium (Ce)	2.0E+00	9.5E+01	2.6E+01	700	1.3E-01	3.7E-02		5.6E-02	1.3E-04	800	0.85E-05	2.3E-07	
Cobalt (Co)	0.9E-01	2.2E+01	6.4E+00	8	2.8E+00	8.0E-01		1.3E-02	2.9E-05	0.8	0.3E-02	1.8E-04	
Cyanide	4.7E-01	1.4E+01	4.0E+00	200	8.0E-02	2.3E-02		8.9E-03	2.1E-05	41	2.2E-04	5.1E-07	
Mercury (Hg)	9.3E-02	1.1E+00	3.2E-01	14	7.7E-02	2.3E-02		6.1E-04	1.4E-06	0.1	6.1E-03	1.4E-05	
Neodymium (Nd)	7.0E+00	2.4E+02	7.0E+01	720	9.3E-01	9.7E-02		1.3E-01	3.1E-04	804	2.7E-04	6.5E-07	
Oxalate	1.2E+02	4.0E+00	1.2E+00	40	0.6E+01	2.0E+01		2.5E+00	5.9E-03	30	1.1E-01	2.6E-04	
TOC (Oxalate C)	3.2E+01	1.1E+03	3.2E+02	80	2.2E+01	0.6E+00		0.1E-01	1.4E-03	18	4.1E-02	0.6E-05	
Selenium (Se)	2.4E-01	8.2E+00	2.4E+00	2	4.1E+00	1.3E+00		4.6E-03	1.1E-05	0.4	1.1E-02	2.7E-05	
Tellurium (Te)	9.3E-01	3.2E+01	9.2E+00	1.4	2.3E+01	0.6E+00		1.8E-02	4.3E-05	0.8	0.6E-02	1.4E-04	
Thallium (Tl)	1.5E+01	5.1E+02	1.5E+02	20	2.6E+01	7.4E+00		2.9E-01	0.8E-04	2	1.4E-01	3.4E-04	
Uranium (U)	3.9E-01	1.3E+01	3.8E+00	20	0.6E-01	1.9E-01		7.3E-03	1.7E-05	10	7.2E-04	1.7E-06	
Vanadium (V)	4.1E-02	1.4E+00	4.1E-01	40	3.5E-02	1.0E-02		7.8E-04	1.8E-06	11	7.1E-05	1.7E-07	
SUM OF FRACTIONS		N/A	N/A	N/A	2.3E+02	0.7E+01		N/A	N/A	N/A	0.3E-01	1.5E-03	
ALLOWABLE RELEASE*		N/A	N/A	N/A	4.4E-03	1.5E-02		N/A	N/A	N/A	1.5E+00	7.0E+02	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-6D. Toxic Chemical Consequences — Unit Releases Flammable Gas Watchlist Tanks 10-2 to 1 yr-1 Frequency - Corrosives.

TABLE E-6D — Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: DST Flammable Gas Watchlist Composite — Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-2 to 10-0 per year — Release Height: Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type		Release Duration			XQs	Release Type		Release Duration			XQs
		Steady State Puff		> 3.5s / < 3.5s			3.4E-2 s/m3 / 9.9E-3/m3	Steady State Puff		> 420 s / < 420 s			1.9E-5 s/m3 / 4.8E-3/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk** Guide PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)		L Fraction of Risk Guide Puff (unitless)
Ammonia (NH3)	7.1E+00	2.4E+02	7.0E+01	0.48	5.0E+02	1.8E+02		1.3E-01	3.9E-04	0.40	2.5E-01		6.8E-04
Barium (Ba)	5.9E+00	2.0E+02	5.8E+01	0.8	3.0E+01	9.4E+00		1.1E-01	2.7E-04	0.5	2.2E-01		5.2E-04
Calcium (Ca)	2.1E+00	7.1E+01	2.1E+01	1	7.1E+01	2.1E+01		4.0E-02	9.5E-05	1	4.0E-02		9.5E-05
Chromium (Cr+3)	2.0E+01	6.7E+02	2.0E+02	2.5	2.6E+02	7.5E+01		3.7E-01	8.8E-04	0.5	7.3E-01		1.8E-03
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	80	0.0E+00	0.0E+00		0.0E+00	0.0E+00	2.2	0.0E+00		0.0E+00
Lantharum (La)	3.0E+01	1.0E+03	3.0E+02	0.9	1.5E+02	4.3E+01		5.7E-01	1.4E-03	0.9	0.3E-02		2.0E-04
Sodium (Na - NaOH)	2.8E+02	9.5E+03	2.8E+03	1.2	7.0E+03	2.3E+03		8.3E+00	1.3E-02	1.2	4.4E+00		1.1E-02
Sod. Hydroxide (NaOH)	2.3E+02	7.8E+03	2.3E+03	2	3.8E+03	1.1E+03		4.4E+00	1.0E-02	2	2.2E+00		8.3E-03
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	1.3E+04	3.7E+03		N/A	N/A	N/A	8.0E+00		1.9E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	7.8E-05	2.7E-04		N/A	N/A	N/A	1.2E-01		5.3E+01

* In units of L/s for steady state releases and units of L for puff releases.
** Lower of PEL-TWA and ERPG-1 used for offsite risk guide

Table E-6E. Toxic Chemical Consequences — Unit Releases Flammable Gas Watchlist Tanks 10-4 to 10-2 yr-1 Frequency - Corrosives.

TABLE E-6E Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: DST Flammable Gas Watchlist Composite — Chemical Inventory: Inventory based on WHC-SD-WM-ER-400

Frequency: 10-4 to 10-2 per year — Release Height: Ground Level

Analyte Type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type			Release Duration		X/Q	Release Type		Release Duration		X/Q	
					> 3.5s		3.4E-2 s/m3	Steady State		> 420 s		1.8E-4 s/m3	
		Puff			< 3.5s		9.9E-3/m3	Puff		< 420 s		4.8E-3/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Ammonia (NH_3)	7.1E+00	2.4E+02	7.0E+01	9.2	2.6E+01	7.6E+00	1.3E-01	9.1E-04	0.40	3.3E-01	6.1E-04
Barium (Ba)	8.9E+00	2.0E+02	5.8E+01	138	1.5E+00	4.3E-01	1.1E-01	7.7E-04	0.8	1.4E-02	3.1E-04
Calcium (Ca)	2.1E+00	7.1E+01	2.1E+01	22	3.2E+00	9.6E-01	4.0E-02	9.6E-04	1	4.4E-02	9.4E-04
Chromium (Cr+3)	2.0E+01	6.8E+02	2.0E+02	81.5	1.3E+01	3.8E+00	3.8E-01	9.0E-04	2.6	1.1E-01	3.1E-04
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	600	0.0E+00	0.0E+00	0.0E+00	0.0E+00	80	0.0E+00	0.0E+00
Lanthanum (La)	3.0E+01	1.0E+03	3.0E+02	197	7.4E+00	2.2E+00	5.7E-01	1.4E-03	0.9	3.2E-02	2.0E-04
Sodium (Na - NaOH)	2.4E+02	9.5E+03	2.8E+03	23	4.1E+02	1.2E+02	5.3E+00	1.2E-02	1.2	4.4E+00	1.1E-02
Sod. Hydroxide (NaOH)	2.3E+02	7.8E+03	2.3E+03	40	2.0E+02	5.7E+01	4.4E+00	1.0E-02	2	2.2E+00	5.5E-03
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	0.0E+02	1.9E+02	N/A	N/A	N/A	7.2E+00	1.7E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	1.5E-03	5.2E-03	N/A	N/A	N/A	1.4E-01	5.8E+01

* In units of L/s for steady state releases and units of L for puff releases.

Table E-6F. Toxic Chemical Consequences — Unit Releases Flammable Gas Watchlist Tanks 10-6 to 10-4 yr-1 Frequency - Corrosives.

TABLE E-6F Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: DST Flammable Gas Watchlist Composite Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-6 to 10-4 per year Release Height: Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)				
		Release Type Steady State Puff		Release Duration > 3.5s < 3.5s		XOs 3.4E-2 s/m3 9.8E-3/m3		Release Type Steady State Puff		Release Duration > 420 s < 420 s		XOs 1.8E-5 s/m3 4.8E-4/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Ammonia (NH3)	7.1E+00	2.4E+02	7.0E+01	23	1.0E+01	3.1E+00		1.3E-01	3.2E-04	0.2	1.8E-02	3.8E-05
Barium (Ba)	5.6E+00	2.0E+02	5.8E+01	344	5.8E-01	1.7E-01		1.1E-01	2.7E-04	139	8.1E-04	1.6E-06
Calcium (Ca)	2.1E+00	7.1E+01	2.1E+01	64	1.3E+00	3.9E-01		4.0E-02	9.8E-05	32	1.8E-03	4.8E-06
Chromium (Cr+3)	2.0E+01	6.8E+02	2.0E+02	120	5.8E+00	1.8E+00		3.8E-01	9.0E-04	51.5	7.4E-03	1.7E-05
Dysprosium (Dy)	8.3E-02	2.8E+00	8.2E-01	800	3.5E-03	1.0E-03		1.6E-03	3.7E-06	800	2.2E-06	6.8E-09
Lanthanum (La)	3.0E+01	1.0E+03	3.0E+02	343	3.0E+00	8.7E-01		6.7E-01	1.4E-03	197	4.3E-03	9.8E-06
Sodium (Na - NaOH)	2.8E+02	9.8E+03	2.8E+03	88	1.4E+02	4.3E+01		6.3E+00	1.5E-02	29	2.2E-01	6.8E-04
Sod. Hydroxide (NaOH)	2.3E+02	7.8E+03	2.3E+03	100	7.8E+01	2.3E+01		4.4E+00	1.0E-02	40	1.1E-01	2.6E-04
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	2.8E+02	7.7E+01		N/A	N/A	N/A	3.7E-01	8.7E-04
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	3.6E-03	1.3E-02		N/A	N/A	N/A	2.7E+00	1.1E+03

* In units of L/s for steady state releases and units of L for puff releases.

Table E-7A. Toxic Chemical Consequences — Unit Releases 50% NaOH 10-2 to 1 yr-1 Frequency.

TABLE E-7A Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: 50% NaOH (Density 1.52 g/ml) Chemical Inventory: 50% NaOH
Frequency: 10-2 to 10-0 per year Release Height: Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State Puff		Release Duration: > 3.6s / < 3.6s		X/Qs: 3.4E-2 s/m3 / 9.0E-3/m3		Release Type: Steady State Puff		Release Duration: > 420 s / < 420 s		X/Qs: 1.9E-5 s/m3 / 4.8E-6/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide** PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)		0.0E+00	0.0E+00	0.40	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.46	0.0E+00	0.0E+00	
Barium (Ba)		0.0E+00	0.0E+00	0.8	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.5	0.0E+00	0.0E+00	
Calcium (Ca)		0.0E+00	0.0E+00	1	0.0E+00	0.0E+00		0.0E+00	0.0E+00	1	0.0E+00	0.0E+00	
Chromium (Cr+3)		0.0E+00	0.0E+00	2.0	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.5	0.0E+00	0.0E+00	
Lanthanum (La)		0.0E+00	0.0E+00	0.9	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.9	0.0E+00	0.0E+00	
Sodium (Na - NaOH)		0.0E+00	0.0E+00	1.2	0.0E+00	0.0E+00		0.0E+00	0.0E+00	1.2	0.0E+00	0.0E+00	
Sod. Hydroxide (NaOH)	7.6E+02	2.6E+04	7.8E+03	2	1.3E+04	3.8E+03		1.4E+01	3.4E-02	2	7.2E+00	1.7E-02	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	1.3E+04	3.8E+03		N/A	N/A	N/A	7.2E+00	1.7E-02	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	7.7E-05	2.7E-04		N/A	N/A	N/A	1.4E-01	5.8E+01	

* In units of L/s for steady state releases and units of L for puff releases.
** lower of PEL-TWA and ERPG-1 used for risk guide

Table E-7B. Toxic Chemical Consequences — Unit Releases - 50% NaOH 10-4 to 10-2 yr-1 Frequency.

TABLE E-7B — Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; uff - 1 L)
Tank/Waste Type: 50% NaPH (Density 1.52 g/ml) — Chemical Inventory: 50% NaPH
Frequency: 10-4 to 10-2 per year — Release Height: Ground Level
Analyte type: Constituents/effluents

A	B	PNSITE (100 Meters)						PFFSITE (Site Boundary)					
		Release Type: Steady State uff		Release Duration: > 3.6s / < 3.6s			X/Qs: 3.4E-2 s/m3 / 0.0E-3/m3	Release Type: Steady State uff		Release Duration: > 420 s / < 420 s		X/Qs: 1.0E-3 s/m3 / 4.6E-5/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D uff Release Consequence (mg/m3)	E Risk Guide ER G-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide uff (unitless)		H Steady State Release Consequence (mg/m3)	I uff Release Consequence (mg/m3)	J Risk Guide ER G-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide uff (unitless)	
Ammonia (NH3)		0.0E+00	0.0E+00	9.2	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.46	0.0E+00	0.0E+00	
Barium (Ba)		0.0E+00	0.0E+00	130	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.8	0.0E+00	0.0E+00	
Calcium (Ca)		0.0E+00	0.0E+00	22	0.0E+00	0.0E+00		0.0E+00	0.0E+00	1	0.0E+00	0.0E+00	
Chromium (Cr+3)		0.0E+00	0.0E+00	51.5	0.0E+00	0.0E+00		0.0E+00	0.0E+00	2.6	0.0E+00	0.0E+00	
Lanthanum (La)		0.0E+00	0.0E+00	137	0.0E+00	0.0E+00		0.0E+00	0.0E+00	6.9	0.0E+00	0.0E+00	
Sodium (Na - NaPH)		0.0E+00	0.0E+00	23	0.0E+00	0.0E+00		0.0E+00	0.0E+00	1.2	0.0E+00	0.0E+00	
Sod. Hydroxide (NaPH)	7.6E+02	2.6E+04	7.8E+03	40	6.5E+02	1.9E+02		1.4E+01	3.4E-02	2	7.2E+00	1.7E-02	
SUM PF FRACTIONS		N/A	N/A	N/A	6.5E+02	1.9E+02		N/A	N/A	N/A	7.2E+00	1.7E-02	
ALLPWABLE RELEASE*		N/A	N/A	N/A	1.5E-03	5.3E-03		N/A	N/A	N/A	1.4E-01	5.8E+01	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-7C. Toxic Chemical Consequences — Unit Releases - 50% NaOH 10-6 to 10-4 yr-1 Frequency.

TABLE E-7C Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: 50% NaOH (Density 1.52 g/ml) Chemical Inventory: 50% NaOH

Frequency: 10-6 to 10-4 per year Release Height: Ground Level

Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State Puff		Release Duration: > 3.6s / < 3.6s		X/Qs: 3.4E-2 s/m3 / 8.9E-3/m3		Release Type: Steady State Puff		Release Duration: > 480 s / < 480 s		X/Qs: 1.8E-5 s/m3 / 4.5E-6/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)		0.0E+00	0.0E+00	23	0.0E+00	0.0E+00		0.0E+00	0.0E+00	8.2	0.0E+00	0.0E+00	
Barium (Ba)		0.0E+00	0.0E+00	341	0.0E+00	0.0E+00		0.0E+00	0.0E+00	190	0.0E+00	0.0E+00	
Calcium (Ca)		0.0E+00	0.0E+00	84	0.0E+00	0.0E+00		0.0E+00	0.0E+00	51.5	0.0E+00	0.0E+00	
Chromium (Cr+3)		0.0E+00	0.0E+00	128	0.0E+00	0.0E+00		0.0E+00	0.0E+00	137	0.0E+00	0.0E+00	
Lanthanum (La)		0.0E+00	0.0E+00	343	0.0E+00	0.0E+00		0.0E+00	0.0E+00	8.9	0.0E+00	0.0E+00	
Sodium (Na - NaOH)		0.0E+00	0.0E+00	50	0.0E+00	0.0E+00		0.0E+00	0.0E+00	23	0.0E+00	0.0E+00	
Sod. Hydroxide (NaOH)	7.6E+02	2.6E+04	7.8E+03	100	2.6E+02	7.8E+01		1.4E+01	3.4E-02	40	3.6E-01	8.6E-04	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	2.6E+02	7.8E+01		N/A	N/A	N/A	3.6E-01	8.6E-04	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	3.8E-03	1.3E-02		N/A	N/A	N/A	2.8E+00	1.2E+03	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-8A. Toxic Chemical Consequences — Unit Releases All-Liquids 10-2 to 1 yr-1 Frequency - Toxics.

TABLE E-8A
TankWaste Type: ALL LIQUIDS
Frequency: 10-2 to 10-0 per year
Analyte type: Toxics

Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Chemical Inventory:
Release Height:

Inventory based on WHC-SD-WM-ER-400
Ground Level

A	B	ONSITE (100 Meters)						OFFSITE (at 3 boundary)						
		Release Type					XiQi	Release Type		Release Duration			XiQi	
		Steady State		Release Duration			3.4E-2 s/m3	Steady State		> 420 s			1.8E-5 s/m3	
		Puff		> 3.5s			9.8E-3/m3	Puff		< 420 s			4.8E-3/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk** Guide PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)		L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	6.4E-03	2.2E-01	6.4E-02	2	1.1E-01	3.8E-02		1.9E-04	2.8E-07	0.5	2.7E-04		1.8E-07	
Arsenic (As)	8.7E-03	3.0E-01	8.8E-02	0.1	3.0E+00	8.6E-01		1.7E-04	3.8E-07	0.01	1.7E-02		3.8E-05	
Beryllium (Be)	3.0E-03	1.3E-01	3.8E-02	0.003	2.2E+01	6.5E+00		7.3E-05	1.7E-07	0.0005	2.4E-01		6.8E-05	
Cadmium (Cd)	7.6E-02	2.4E+00	6.9E-01	0.2	1.2E+01	3.5E+00		1.7E-03	3.9E-06	0.005	2.7E-01		6.3E-04	
Cerium (Ce)	1.8E+00	6.0E+01	1.7E+01	70	8.5E-01	2.2E-01		3.3E-02	7.8E-05	2	1.7E-02		3.8E-03	
Cobalt (Co)	8.1E-03	3.0E-01	8.7E-02	0.05	6.0E+00	1.7E+00		1.7E-04	4.0E-07	0.05	3.5E-03		7.8E-04	
Cyanide	0.3E+00	1.1E+02	3.2E+01	5	2.3E+01	1.1E+01		1.0E-01	2.4E-04	5	2.0E-02		4.6E-03	
Mercury (Hg)	3.1E-01	1.1E+01	3.1E+00	0.075	1.4E+02	4.1E+01		6.6E-03	1.4E-05	0.05	1.3E-01		2.8E-04	
Neodymium (Nd)	1.4E-01	4.8E+00	1.4E+00	72	6.1E-02	2.0E-02		2.7E-03	6.0E-06	3.6	7.5E-04		1.8E-04	
Oxalate	0.0E+00	0.0E+00	0.0E+00	4	0.0E+00	0.0E+00		0.0E+00	0.0E+00	1	0.0E+00		0.0E+00	
Non-volatile TOC	4.0E+01	1.4E+03	4.0E+02	3	4.5E+02	1.3E+02		7.9E-01	1.8E-03	2.5	3.8E-01		7.3E-04	
Selenium (Se)	2.8E-01	9.8E+00	2.8E+00	0.2	4.8E+01	1.4E+01		5.5E-03	1.3E-05	0.2	2.7E-02		6.3E-05	
Tellurium (Te)	2.7E-03	9.2E-02	2.7E-02	0.13	7.1E-01	2.1E-01		5.1E-06	1.2E-07	0.1	5.1E-04		1.2E-06	
Thallium (Tl)	3.7E-02	1.3E+00	3.7E-01	0.3	4.2E+00	1.2E+00		7.0E-04	1.7E-06	0.1	7.0E-03		1.7E-05	
Uranium (U)	1.1E+01	3.7E+02	1.1E+02	1	3.7E+02	1.1E+02		2.1E-01	5.0E-04	0.2	1.0E+00		2.3E-03	
Vanadium (V)	4.1E-03	1.4E-01	4.0E-02	1.2	1.1E-01	3.5E-02		7.7E-06	1.8E-07	0.03	2.6E-03		6.1E-06	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	1.1E+03	3.2E+02		N/A	N/A	N/A	1.0E+00		4.4E-03	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	9.1E-04	3.1E-03		N/A	N/A	N/A	9.4E-01		2.3E+02	

* In units of L/s for steady state releases and units of L for puff releases.
** Lower of PEL-TWA and ERPG-1 used for offsite risk guidelines

Table E-8B. Toxic Chemical Consequences — Unit Releases All-Liquids 10-4 to 10-2 yr-1 Frequency - Toxics.

TABLE E-8B Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: ALL LIQUIDS — Chemical Inventory: Inventory based on WHC-SD-WM-ER-400

Frequency: 10-4 to 10-2 per year — Release Height: Ground Level

Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (95m Boundary)					
		Release Type: Steady State Puff		Release Duration: > 3.6s / < 3.6s		χ/Qs: 3.4E-2 s/m3 / 9.9E-3/m3		Release Type: Steady State Puff		Release Duration: > 420 s / < 420 s		χ/Qs: 1.8E-5 s/m3 / 4.8E-6/m3	
Analyte	Analyte Concentration (mg/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)		
Antimony (Sb)	6.4E-03	2.2E-01	6.4E-02	40	5.5E-03	1.8E-03	1.2E-04	2.1E-07	2	6.1E-05	1.4E-07		
Arsenic (As)	8.7E-03	3.0E-01	8.6E-02	7	4.3E-02	1.2E-02	1.7E-04	3.1E-07	0.1	1.7E-03	3.1E-06		
Beryllium (Be)	3.8E-03	1.3E-01	3.8E-02	0.026	5.2E+00	1.5E+00	7.2E-05	1.7E-07	0.003	1.8E-02	2.5E-05		
Cadmium (Cd)	7.0E-02	2.4E+00	0.9E-01	1	2.4E+00	0.9E-01	1.3E-03	3.3E-06	0.2	0.7E-03	1.6E-05		
Calcium (Ca)	1.8E+00	6.0E+01	1.7E+01	500	1.2E-01	3.5E-02	3.3E-02	7.8E-05	70	4.8E-04	1.1E-03		
Cobalt (Co)	8.8E-03	3.0E-01	0.7E-02	0.2	1.5E+00	4.4E-01	1.7E-04	4.0E-07	0.05	3.2E-03	7.3E-06		
Cyanide	5.3E+00	1.8E+02	5.3E+01	41	4.4E+00	1.3E+00	1.0E-01	2.4E-04	5	2.0E-02	4.6E-06		
Mercury (Hg)	3.1E-01	1.1E+01	3.1E+00	0.1	1.1E+02	3.1E+01	5.8E-03	1.4E-05	0.078	7.6E-02	1.6E-04		
Neodymium (Nd)	1.4E-01	4.8E+00	1.4E+00	804	0.7E-03	2.0E-03	2.7E-03	6.3E-06	72	3.8E-03	8.6E-06		
Oxalate	0.0E+00	0.0E+00	0.0E+00	20	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4	0.0E+00	0.0E+00		
TOC-Oxalate C	4.0E+01	1.4E+03	4.0E+02	15	9.1E+01	2.6E+01	7.4E-01	1.8E-03	3	2.4E-01	5.6E-04		
Selenium (Se)	2.8E-01	9.8E+00	2.8E+00	0.4	2.4E+01	6.9E+00	5.3E-03	1.2E-05	0.2	2.7E-02	6.2E-05		
Tellurium (Te)	2.7E-03	9.2E-02	2.7E-02	0.3	3.1E-01	8.9E-02	5.1E-05	1.2E-07	0.13	3.8E-04	8.9E-07		
Thallium (Tl)	3.7E-02	1.3E+00	3.7E-01	2	0.3E-01	1.8E-01	7.0E-04	1.7E-06	0.3	2.3E-03	5.5E-06		
Uranium (U)	1.1E+01	3.7E+02	1.1E+02	10	3.7E+01	1.1E+01	2.1E-01	5.0E-04	1	2.1E-01	5.0E-04		
Vanadium (V)	4.1E-03	1.4E-01	4.0E-02	11	1.3E-02	3.8E-03	7.7E-05	1.8E-07	1.2	8.4E-05	1.9E-07		
SUM OF FRACTIONS		N/A	N/A	N/A	2.7E+02	7.9E+01	N/A	N/A	N/A	0.1E-01	1.3E-03		
ALLOWABLE RELEASE*		N/A	N/A	N/A	3.7E-03	1.3E-02	N/A	N/A	N/A	1.0E+00	0.0E+02		

* In units of L/s for steady state releases and units of L for puff releases.

Table E-8C. Toxic Chemical Consequences — Unit Releases All-Liquids 10-6 to 10-4 yr-1 Frequency - Toxics.

TABLE E-8C Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: ALL LIQUIDS — Chemical Inventory: Inventory based on WHC-SD-WM-ER-400

Frequency: 10-6 to 10-4 per year — Release Height: Ground Level

Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.5s / < 3.5s		X/Qs: 3.4E-2 s/m3 / 9.8E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s		X/Qs: 1.8E-5 s/m3 / 4.8E-6/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	6.4E-03	2.2E-01	6.4E-02	70	3.1E-03	9.1E-04		1.2E-04	2.6E-07	40	3.1E-04	7.2E-08	
Arsenic (As)	8.7E-03	3.0E-01	8.6E-02	40	7.4E-03	2.2E-03		1.7E-04	3.5E-07	7	2.4E-03	5.0E-08	
Beryllium (Be)	3.8E-03	1.3E-01	3.8E-02	0.1	1.3E+00	3.8E-01		7.2E-05	1.7E-07	0.028	2.8E-03	6.8E-08	
Cadmium (Cd)	7.0E-02	2.4E+00	6.9E-01	10	2.4E-01	6.9E-02		1.3E-03	3.2E-06	1	1.2E-03	3.2E-08	
Cerium (Ce)	1.8E+00	6.0E+01	1.7E+01	700	0.0E-02	2.5E-02		3.5E-02	7.8E-05	500	0.7E-03	1.0E-07	
Cobalt (Co)	8.6E-03	3.0E-01	8.7E-02	8	3.7E-02	1.1E-02		1.7E-04	4.0E-07	0.2	0.4E-04	2.0E-06	
Cyanide	5.3E+00	1.8E+02	5.3E+01	200	9.0E-01	2.6E-01		1.0E-01	2.4E-04	41	2.8E-03	5.8E-06	
Mercury (Hg)	3.1E-01	1.1E+01	3.1E+00	14	7.5E-01	2.2E-01		5.0E-03	1.4E-05	0.1	6.8E-03	1.4E-04	
Neodymium (Nd)	1.4E-01	4.8E+00	1.4E+00	720	6.8E-03	2.0E-03		2.7E-03	6.5E-06	804	8.4E-06	1.9E-08	
Oxalate	0.0E+00	0.0E+00	0.0E+00	40	0.0E+00	0.0E+00		0.0E+00	0.0E+00	20	0.0E+00	0.0E+00	
TOC-Oxalate C	4.0E+01	1.4E+03	4.0E+02	50	2.7E+01	7.8E+00		7.8E-01	1.8E-03	15	6.1E-02	1.3E-04	
Selenium (Se)	2.6E-01	8.8E+00	2.6E+00	2	4.6E+00	1.4E+00		8.5E-03	1.3E-05	0.4	1.3E-01	3.8E-05	
Tellurium (Te)	2.7E-03	9.2E-02	2.7E-02	1.4	6.0E-02	1.8E-02		8.1E-06	1.2E-07	0.3	1.7E-04	4.1E-07	
Thallium (Tl)	3.7E-02	1.3E+00	3.7E-01	20	0.3E-02	1.8E-02		7.0E-04	1.7E-06	2	3.5E-04	8.3E-07	
Uranium (U)	1.1E+01	3.7E+02	1.1E+02	20	1.9E+01	5.4E+00		2.1E-01	5.0E-04	10	2.1E-02	5.0E-05	
Vanadium (V)	4.1E-03	1.4E-01	4.0E-02	40	3.4E-03	1.0E-03		7.7E-05	1.8E-07	11	7.0E-06	1.7E-08	
SUM OF FRACTIONS		N/A	N/A	N/A	5.4E+01	1.6E+01		N/A	N/A	N/A	1.8E-01	3.8E-04	
ALLOWABLE RELEASE*		N/A	N/A	N/A	1.8E-02	6.3E-02		N/A	N/A	N/A	6.0E+00	2.6E+03	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-8D. Toxic Chemical Consequences — Unit Releases All-Liquids 10-2 to 1 yr-1 Frequency - Corrosives.

TABLE E-8D Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: ALL LIQUIDS Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-2 to 10-0 per year Release Height: Ground Level
Analyte type: Corrosives/Alkalis

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State Puff		Release Duration: > 3.5s / < 3.5s		XOs: 3.4E-2 s/m3 / 9.9E-3s/m3		Release Type: Steady State Puff		Release Duration: > 420 s / < 420 s		XOs: 1.9E-5 s/m3 / 4.8E-6s/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide** PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	7.1E+00	2.4E+02	7.0E+01	0.46	5.2E+02	1.5E+02		1.3E-01	3.3E-04	0.49	2.6E-01	6.8E-04	
Barium (Ba)	6.3E-02	1.8E+00	5.2E-01	0.5	2.7E-01	7.7E-03		1.0E-03	2.4E-06	0.5	2.0E-03	4.8E-06	
Calcium (Ca)	1.3E+00	4.4E+01	1.3E+01	1	4.4E+01	1.3E+01		2.8E-02	6.8E-05	1	2.8E-02	6.8E-05	
Chromium (Cr+3)	0.0E+00	0.0E+00	0.0E+00	2.5	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.5	0.0E+00	0.0E+00	
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	50	0.0E+00	0.0E+00		0.0E+00	0.0E+00	2.2	0.0E+00	0.0E+00	
Lanthanum (La)	1.0E+00	3.4E+01	9.9E+00	0.5	4.8E+00	1.4E+00		1.9E-02	4.8E-05	0.5	3.8E-02	9.5E-05	
Sodium (Na - NaOH)	2.1E+02	7.1E+03	2.1E+03	1.2	6.0E+03	1.7E+03		4.0E+00	9.8E-03	1.2	3.3E+00	7.8E-03	
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	2	3.6E+03	1.0E+03		4.0E+00	9.8E-03	2	2.0E+00	4.7E-03	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	1.0E+04	2.9E+03		N/A	N/A	N/A	5.6E+00	1.3E-02	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	9.9E-05	3.4E-04		N/A	N/A	N/A	1.8E-01	7.5E+01	

* In units of L/s for steady state releases and units of L for puff releases.
** Lower of PEL-TWA and ERPG-1 used for offsite risk guide

Table E-8E. Toxic Chemical Consequences — Unit Releases All-Liquids 10-4 to 10-2 yr-1 Frequency - Corrosives.

TABLE E-8E Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: ALL LIQUIDS — Chemical Inventory: Inventory based on WHC-SD-WM-ER-400

Frequency: 10-4 to 10-2 per year — Release Height: Ground Level

Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)					OFFSITE (Site Boundary)				
		Release Type		Release Duration		X/Q	Release Type		Release Duration		X/Q
		Steady State		> 3.5s		3.4E-2 s/m3	Steady State		> 420 s		1.0E-5 s/m3
		Puff		< 3.5s		9.9E-3/m3	Puff		< 420 s		4.8E-4/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Ammonia (NH3)	7.1E+00	2.4E+02	7.0E+01	82	2.9E+01	7.0E+00	1.3E-01	3.3E-04	0.46	2.8E-01	6.9E-04
Barium (Ba)	5.3E-02	1.8E+00	5.2E-01	138	1.3E-02	3.8E-03	1.0E-03	2.4E-06	0.8	1.8E-04	3.9E-07
Calcium (Ca)	1.3E+00	4.4E+01	1.3E+01	22	2.0E+00	5.1E-01	2.5E-02	5.9E-05	1	2.5E-02	5.9E-05
Chromium (Cr+3)	0.0E+00	0.0E+00	0.0E+00	51.5	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.6	0.0E+00	0.0E+00
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	600	0.0E+00	0.0E+00	0.0E+00	0.0E+00	80	0.0E+00	0.0E+00
Lanthanum (La)	1.0E+00	3.4E+01	9.9E+00	137	2.5E-01	7.2E-02	1.9E-02	4.5E-05	0.9	2.1E-03	5.0E-03
Sodium (Na - NaOH)	2.1E+02	7.1E+03	2.1E+03	23	3.1E+02	9.0E+01	4.0E+00	9.5E-03	1.2	3.3E+00	7.9E-03
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	40	1.8E+02	5.2E+01	4.0E+00	9.5E-03	2	2.0E+00	4.7E-03
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	5.2E+02	1.5E+02	N/A	N/A	N/A	5.8E+00	1.3E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	1.9E-03	6.6E-03	N/A	N/A	N/A	1.8E-01	7.5E+01

* In units of L/s for steady state releases and units of L for puff releases.

Table E-8F. Toxic Chemical Consequences — Unit Releases All-Liquids 10-4 to 10-6 yr-1 Frequency - Corrosives.

TABLE E-8F Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: ALL LIQUIDS Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-6 to 10-4 per year Release Height: Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type			Release Duration		X/Qs	Release Type			Release Duration		X/Qs
		Steady State Puff			> 3.5s < 3.5s		3.4E-2 s/m3 9.9E-3/m3	Steady State Puff			> 420 s < 420 s		1.9E-5 s/m3 4.8E-6/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	7.1E+00	2.4E+02	7.0E+01	23	1.0E+01	3.1E+00		1.3E-01	3.3E-04	0.2	1.8E-02	3.9E-05	
Barium (Ba)	5.3E-02	1.8E+00	5.2E-01	344	5.2E-03	1.5E-03		1.0E-03	2.4E-06	150	7.3E-06	1.7E-08	
Calcium (Ca)	1.3E+00	4.4E+01	1.3E+01	64	9.2E-01	2.4E-01		2.5E-02	5.9E-05	22	1.1E-03	2.7E-06	
Chromium (Cr+3)	0.0E+00	0.0E+00	0.0E+00	129	0.0E+00	0.0E+00		0.0E+00	0.0E+00	51.5	0.0E+00	0.0E+00	
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	800	0.0E+00	0.0E+00		0.0E+00	0.0E+00	600	0.0E+00	0.0E+00	
Lanthanum (La)	1.0E+00	3.4E+01	9.8E+00	343	9.9E-02	2.9E-02		1.9E-02	4.5E-05	137	1.4E-04	3.3E-07	
Sodium (Na - NaOH)	2.1E+02	7.1E+03	2.1E+03	59	1.2E+02	3.6E+01		4.0E+00	9.5E-03	23	1.7E-01	4.1E-04	
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	100	7.1E+01	2.1E+01		4.0E+00	9.5E-03	40	1.0E-01	2.4E-04	
SUM OF FRACTIONS		N/A	N/A	N/A	2.1E+02	6.0E+01		N/A	N/A	N/A	2.9E-01	0.0E-04	
ALLOWABLE RELEASE*		N/A	N/A	N/A	4.9E-03	1.7E-02		N/A	N/A	N/A	3.5E+00	1.5E+03	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-9A. Toxic Chemical Consequences — Unit Releases All-Solids 10-2 to 1 yr-1 Frequency - Toxics.

TABLE E-9A Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L) Inventory based on WHC-SD-WM-ER-400

Tank/Waste Type: All Solids Chemical Inventory:

Frequency: 10-2 to 10-0 per year Release Height: Ground Level

Analyte type: Toxics

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State / Puff		Release Duration: > 3.6s / < 3.6s		X/Qs: 3.4E-2 s/m3 / 9.9E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s		X/Qs: 1.9E-5 s/m3 / 4.8E-5/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk** Guide PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	1.5E+00	5.1E+01	1.9E+01	2	2.6E+01	7.4E+00		2.9E-02	6.9E-05	0.5	5.7E-02	1.4E-04	
Arsenic (As)	5.7E+00	1.9E+02	6.8E+01	0.1	1.9E+03	5.4E+02		1.1E-01	2.6E-04	0.01	1.1E+01	2.6E-02	
Beryllium (Be)	1.4E-01	4.8E+00	1.4E+00	0.005	7.8E+02	2.2E+02		2.7E-03	6.3E-06	0.002	1.3E+00	3.3E-03	
Cadmium (Cd)	2.6E+01	8.8E+02	2.6E+02	0.2	4.4E+03	1.3E+03		4.9E-01	1.2E-03	0.005	9.8E+01	2.3E-01	
Cerium (Ce)	2.6E+00	8.6E+01	2.6E+01	70	1.3E+00	3.7E-01		4.9E-02	1.2E-04	2	9.8E-02	6.6E-03	
Cobalt (Co)	0.5E-01	2.2E+01	6.4E+00	0.05	4.4E+02	1.3E+02		1.2E-02	2.9E-05	0.05	2.5E-01	5.9E-04	
Cyanide	2.6E+00	9.5E+01	2.6E+01	5	1.9E+01	5.5E+00		5.3E-02	1.3E-04	5	1.1E-02	2.5E-05	
Mercury (Hg)	5.4E+01	1.8E+03	5.5E+02	0.075	2.4E+04	7.1E+03		1.0E+00	2.4E-03	0.05	2.1E+01	4.9E-03	
Neodymium (Nd)	7.0E+00	2.4E+02	6.8E+01	72	3.5E+00	9.6E-01		1.3E-01	3.2E-04	3.5	3.8E-02	9.0E-05	
Oxalate	2.6E+02	9.4E+03	2.7E+03	4	2.3E+03	6.6E+02		5.2E+00	1.2E-02	1	5.2E+00	1.2E-02	
TOC-Oxalate C	7.5E+01	2.6E+03	7.4E+02	3	6.8E+02	2.0E+02		1.4E+00	3.4E-03	2.5	5.7E-01	1.4E-03	
Selenium (Se)	3.5E+00	1.2E+02	3.6E+01	0.2	9.0E+02	1.7E+02		6.7E-02	1.6E-04	0.2	3.3E-01	7.8E-04	
Tellurium (Te)	9.3E-01	3.2E+01	9.2E+00	0.13	2.4E+02	7.1E+01		1.8E-02	4.3E-05	0.1	1.8E-01	4.2E-04	
Thallium (Tl)	1.5E+01	5.1E+02	1.5E+02	0.3	1.7E+03	5.0E+02		2.0E-01	6.6E-04	0.1	2.0E+00	6.8E-03	
Uranium (U)	2.6E+02	9.7E+03	2.6E+03	1	9.7E+03	2.8E+03		5.4E+00	1.3E-02	0.2	2.7E+01	6.4E-02	
Vanadium (V)	4.1E-02	1.4E+00	4.1E-01	1.2	1.2E+00	3.4E-01		7.8E-04	1.8E-06	0.03	2.6E-02	6.3E-05	
SUM OF FRACTIONS		N/A	N/A	N/A	4.6E+04	1.4E+04		N/A	N/A	N/A	1.7E+02	4.0E-01	
ALLOWABLE RELEASE*		N/A	N/A	N/A	2.1E-05	7.2E-05		N/A	N/A	N/A	6.0E-03	2.5E+00	

* In units of L/s for steady state releases and units of L for puff releases.

** Lower of PEL-TWA and ERPG-1 used for offsite risk guideline

Table E-9B. Toxic Chemical Consequences — Unit Releases All-Solids 10-4 to 10-2 yr-1 Frequency - Toxics.

TABLE E-9B Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: All solids — Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-4 to 10-2 per year — Release Height: Ground Level
Analyte type: Toxics

A	B	ONSITE (100 Meters)					OFFSITE (Site Boundary)				
		Release Type: Steady State / Puff		Release Duration: > 3.5s / < 3.5s		X/Q: 3.4E-2 s/m3 / 9.0E-3/m3	Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s		X/Q: 1.5E-5 s/m3 / 4.0E-4/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Antimony (Sb)	1.5E+00	5.1E+01	1.5E+01	40	1.3E+00	3.7E-01	2.9E-02	8.8E-05	2	1.4E-02	3.4E-05
Arsenic (As)	5.7E+00	1.9E+02	5.6E+01	7	2.6E+01	8.1E+00	1.1E-01	2.6E-04	0.1	1.1E+00	2.6E-03
Beryllium (Be)	1.4E-01	4.6E+00	1.4E+00	0.025	1.8E+02	5.5E+01	2.7E-03	6.3E-06	0.006	4.4E-01	1.1E-03
Cadmium (Cd)	2.6E+01	8.8E+02	2.6E+02	1	8.8E+02	2.6E+02	4.1E-01	1.2E-03	0.2	2.9E+00	6.9E-03
Cerium (Ce)	2.6E+00	8.8E+01	2.6E+01	500	1.8E-01	5.1E-02	4.1E-02	1.2E-04	70	7.1E-04	1.7E-03
Cobalt (Co)	9.5E-01	2.2E+01	6.4E+00	0.2	1.1E+02	3.2E+01	1.2E-02	2.9E-05	0.05	2.5E-01	5.9E-04
Cyanide	2.8E+00	9.5E+01	2.8E+01	41	2.3E+00	6.8E-01	5.5E-02	1.3E-04	5	1.1E-02	2.6E-05
Mercury (Hg)	5.4E+01	1.8E+03	5.3E+02	0.1	1.0E+04	5.3E+03	1.0E+00	2.4E-03	0.075	1.4E+01	3.3E-02
Neodymium (Nd)	7.0E+00	2.4E+02	6.9E+01	504	4.7E-01	1.4E-01	1.3E-01	3.2E-04	72	1.8E-03	4.4E-06
Oxalate	2.8E+02	9.4E+03	2.7E+03	20	4.7E+02	1.4E+02	5.2E+00	1.2E-02	4	1.2E+00	3.1E-03
TOC-Oxalate	7.5E+01	2.6E+03	7.4E+02	15	1.7E+02	5.0E+01	1.4E+00	3.4E-03	3	4.8E-01	1.1E-03
Selenium (Se)	3.8E+00	1.2E+02	3.6E+01	0.4	3.0E+02	8.7E+01	8.7E-02	1.6E-04	0.2	3.5E-01	7.8E-04
Tellurium (Te)	9.3E-01	3.2E+01	9.2E+00	0.3	1.1E+02	3.1E+01	1.6E-02	4.2E-05	0.13	1.4E-01	3.2E-04
Thallium (Tl)	1.5E+01	5.1E+02	1.5E+02	2	2.6E+02	7.4E+01	2.0E-01	6.8E-04	0.3	9.8E-01	2.3E-03
Uranium (U)	2.6E+02	9.7E+03	2.8E+03	10	9.7E+02	2.8E+02	5.4E+00	1.3E-02	1	5.4E+00	1.3E-02
Vanadium (V)	4.1E-02	1.4E+00	4.1E-01	11	1.3E-01	3.7E-02	7.8E-04	1.8E-06	1.2	6.8E-04	1.5E-06
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	2.2E+04	6.4E+03	N/A	N/A	N/A	2.7E+01	6.3E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	4.6E-05	1.6E-04	N/A	N/A	N/A	3.6E-02	1.6E+01

* In units of L/s for steady state releases and units of L for puff releases.

Table E-9C. Toxic Chemical Consequences — Unit Releases All-Solids 10-4 to 10-6 yr-1 frequency - Toxics.

TABLE E-9C Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: All Solids Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-6 to 10-4 per year Release Height: Ground Level
Analyte type: Toxics

A	B	ONSITE (100 Meters)						Release Type	OFFSITE (95m Boundary)					
		Release Type: Steady State Puff		Release Duration: > 3.5s / < 3.5s			X/Q: 3.4E-2 s/m3 / 9.9E-3/m3	Release Type: Steady State Puff	Release Duration: > 420 s / < 420 s				X/Q: 1.9E-5 s/m3 / 4.8E-6/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	1.5E+00	5.1E+01	1.8E+01	70	7.3E-01	2.1E-01		2.9E-02	6.8E-05	40	7.1E-04	1.7E-06	
Arsenic (As)	5.7E+00	1.9E+02	5.0E+01	40	4.8E+00	1.4E+00		1.1E-01	2.6E-04	7	1.8E-02	9.7E-06	
Beryllium (Be)	1.4E-01	4.8E+00	1.4E+00	0.1	4.8E+01	1.4E+01		2.7E-03	6.3E-06	0.025	1.1E-01	2.8E-04	
Cadmium (Cd)	2.6E+01	9.8E+02	2.6E+02	10	9.8E+01	2.6E+01		4.8E-01	1.2E-03	1	4.8E-01	1.2E-03	
Cerium (Ce)	2.6E+00	8.8E+01	2.6E+01	700	1.3E-01	3.7E-02		4.8E-02	1.2E-04	600	8.0E-05	2.1E-07	
Cobalt (Co)	0.5E-01	2.2E+01	6.4E+00	8	2.8E+00	8.0E-01		1.2E-02	2.8E-05	0.2	1.3E-02	1.8E-04	
Cyanide	2.8E+00	9.5E+01	2.6E+01	800	4.8E-01	1.4E-01		5.3E-02	1.3E-04	41	1.3E-03	3.1E-06	
Mercury (Hg)	5.4E+01	1.8E+03	5.3E+02	14	1.3E+02	3.8E+01		1.0E+00	2.4E-03	0.1	1.0E+01	2.4E-02	
Neodymium (Nd)	7.0E+00	2.4E+02	6.9E+01	720	3.5E-01	9.8E-02		1.3E-01	3.2E-04	504	2.8E-04	6.8E-07	
Oxalate	2.8E+02	9.4E+03	2.7E+03	40	2.3E+02	6.8E+01		5.2E+00	1.2E-02	20	2.8E-01	6.8E-04	
TOC-Oxalate C	7.5E+01	2.6E+03	7.4E+02	80	5.1E+01	1.5E+01		1.4E+00	3.4E-03	16	0.5E-02	2.9E-04	
Selenium (Se)	3.8E+00	1.2E+02	3.5E+01	2	8.0E+01	1.7E+01		9.7E-02	1.6E-04	0.4	1.7E-01	3.9E-04	
Tellurium (Te)	0.3E+01	3.2E+01	9.2E+00	1.4	2.3E+01	6.6E+00		1.8E-02	4.2E-05	0.8	0.6E-02	1.4E-04	
Thallium (Tl)	1.5E+01	5.1E+02	1.5E+02	20	2.0E+01	7.4E+00		2.6E-01	6.0E-04	2	1.4E-01	3.4E-04	
Uranium (U)	2.8E+02	9.7E+03	2.8E+03	20	4.8E+02	1.4E+02		5.4E+00	1.3E-02	10	5.4E-01	1.3E-03	
Vanadium (V)	4.1E-02	1.4E+00	4.1E-01	40	3.8E-02	1.0E-02		7.6E-04	1.8E-06	11	7.1E-05	1.7E-07	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	1.2E+03	3.4E+02		N/A	N/A	N/A	1.2E+01	2.8E-02	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	8.7E-04	3.0E-03		N/A	N/A	N/A	8.3E-02	3.5E+01	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-9D. Toxic Chemical Consequences — Unit Releases All-Solids 10-2 to 1 yr-1 Frequency - Corrosives.

TABLE E-9D Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: ALL SOLIDS Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-2 to 10-0 per year Release Height: Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type		Release Duration		X/Q:		Release Type		Release Duration		X/Q:	
		Steady State Puff		> 3.5s < 3.5s		3.4E-2 s/m3 0.9E-3/m3		Steady State Puff		> 420 s < 420 s		1.9E-5 s/m3 4.8E-6/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide** PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	6.6E+00	2.2E+02	6.5E+01	0.48	4.6E+02	1.4E+02		1.3E-01	3.0E-04	0.48	2.7E-01	6.5E-04	
Barium (Ba)	4.0E+01	1.4E+03	3.9E+02	0.8	2.0E+02	5.8E+01		7.6E-01	1.8E-03	0.5	1.5E+00	3.8E-03	
Calcium (Ca)	5.1E+01	1.7E+03	5.0E+02	1	1.7E+03	5.0E+02		9.7E-01	2.3E-03	1	8.7E-01	2.3E-03	
Chromium (Cr+3)	1.5E+02	5.1E+03	1.5E+03	2.0	2.0E+03	5.7E+02		2.9E+00	6.8E-03	0.5	5.7E+00	1.4E-02	
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	00	0.0E+00	0.0E+00		0.0E+00	0.0E+00	2.2	0.0E+00	0.0E+00	
Lanthanum (La)	5.0E+01	1.7E+03	5.0E+02	0.8	2.5E+02	7.2E+01		9.8E-01	2.3E-03	0.9	1.4E-01	3.3E-04	
Sodium (Na - NaOH)	4.0E+02	1.6E+04	4.8E+03	1.2	1.4E+04	4.0E+03		0.1E+00	2.2E-02	1.2	7.6E+00	1.8E-02	
Sod. Hydroxide (NaOH)	2.3E+02	7.6E+03	2.3E+03	2	3.8E+03	1.1E+03		4.4E+00	1.0E-02	2	2.5E+00	5.2E-03	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	2.2E+04	0.4E+03		N/A	N/A	N/A	1.8E+01	4.4E-02	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	4.5E-05	1.6E-04		N/A	N/A	N/A	5.4E-02	2.3E+01	

* In units of L/s for steady state releases and units of L for puff releases.
** lower of PEL-TWA and ERPG-1 are used for offsite calculation

Table E-9E. Toxic Chemical Consequences — Unit Releases All-Solids 10-4 to 10-2 yr-1 Frequency - Corrosives.

TABLE E-9E Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: ALL SOLIDS — Chemical Inventory; Inventory based on WHC-SD-WM-ER-400

Frequency: 10-4 to 10-2 per year — Release Height: Ground Level

Analyte type: Corrosives/Alkalis

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State Release / Puff		Release Duration: > 3.5s / < 3.5s		X/Qs: 3.4E-2 s/m3 / 9.9E-3/m3		Release Type: Steady State / Puff		Release Duration: > 420 s / < 420 s		X/Qs: 1.8E-5 s/m3 / 4.8E-6/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	6.6E+00	2.2E+02	6.5E+01	82	2.4E+01	7.1E+00		1.3E-01	3.0E-04	0.46	2.7E-01	6.5E-04	
Barium (Ba)	4.0E+01	1.4E+03	3.9E+02	138	9.8E+00	2.8E+00		7.8E-01	1.8E-03	0.8	1.1E-01	2.3E-04	
Calcium (Ca)	5.1E+01	1.7E+03	5.0E+02	22	7.6E+01	2.2E+01		9.7E-01	2.3E-03	1	8.7E-01	2.3E-03	
Chromium (Cr+3)	1.5E+02	5.1E+03	1.5E+03	51.5	9.9E+01	2.8E+01		2.9E+00	6.8E-03	2.8	1.1E+00	2.6E-03	
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	600	0.0E+00	0.0E+00		0.0E+00	0.0E+00	60	0.0E+00	0.0E+00	
Lanthanum (La)	3.3E+01	1.1E+03	3.3E+02	137	8.2E+00	2.4E+00		9.3E-01	1.5E-03	0.9	9.1E-02	2.2E-04	
Sodium (Na - NaOH)	4.8E+02	1.6E+04	4.6E+03	23	7.1E+02	2.1E+02		9.1E+00	2.2E-02	1.2	7.6E+00	1.8E-02	
Sod. Hydroxide (NaOH)	2.3E+02	7.8E+03	2.3E+03	40	2.0E+02	5.7E+01.		4.4E+00	1.0E-02	2	2.5E+00	5.9E-03	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	1.1E+03	3.3E+02		N/A	N/A	N/A	1.5E+01	2.8E-02	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	0.0E-04	3.1E-03		N/A	N/A	N/A	8.1E-02	3.4E+01	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-9F. Toxic Chemical Consequences — Unit Releases All-Solids 10-6 to 10-4 yr-1 Frequency - Corrosives.

TABLE E-9F Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: Single Shell Tanks/Solids Chemical Inventory: Inventory based on WHC-SD-WM-ER-400
Frequency: 10-6 to 10-4 per year Release Height: Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type		Release Duration			X/Q	Release Type		Release Duration			X/Q
		Steady State		> 3.5s			3.4E-2 s/m3	Steady State		> 420 s			1.8E-5 s/m3
		Puff		< 3.5s			9.9E-3/m3	Puff		< 420 s			4.8E-3/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Ammonia (NH3)	8.6E+00	2.2E+02	8.5E+01	23	9.8E+00	2.0E+00		1.3E-01	9.0E-04	0.2	1.4E-02	3.9E-03	
Barium (Ba)	4.0E+01	1.4E+03	3.9E+02	344	3.9E+00	1.1E+00		7.0E-01	1.8E-03	138	5.0E-03	1.3E-05	
Calcium (Ca)	5.1E+01	1.7E+03	5.0E+02	64	3.2E+01	9.4E+00		9.7E-01	2.3E-03	22	4.4E-02	1.0E-04	
Chromium (Cr+3)	1.5E+02	5.1E+03	1.5E+03	129	4.0E+01	1.2E+01		2.9E+00	6.8E-03	51.3	0.0E-02	1.3E-04	
Dysprosium (Dy)	0.3E-02	2.6E+00	0.2E-01	600	3.5E-03	1.0E-03		1.0E-03	3.7E-06	600	2.2E-06	0.2E-09	
Lanthanum (La)	5.0E+01	1.7E+03	5.0E+02	343	5.0E+00	1.4E+00		9.0E-01	2.3E-03	137	0.0E-03	1.6E-05	
Sodium (Na - NaOH)	4.8E+02	1.6E+04	4.6E+03	58	2.8E+02	8.5E+01		9.1E+00	2.2E-02	23	4.0E-01	9.4E-04	
Sod. Hydroxide (NaOH)	2.3E+02	7.8E+03	2.3E+03	100	7.8E+01	2.3E+01		4.4E+00	1.0E-02	40	1.1E-01	2.6E-04	
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	4.5E+02	1.3E+02		N/A	N/A	N/A	0.3E-01	1.8E-03	
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	2.2E-03	7.6E-03		N/A	N/A	N/A	1.0E+00	0.7E+02	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-10A. Toxic Chemical Consequences — Unit Releases C-106 10-2 to 1 yr-1 Frequency - Toxics.

TABLE E-10A
Tank/Waste Type: C-106 SOLIDS
Frequency: 10-2 to 10-0 per year
Analyte type: Toxics
Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Chemical Inventory: C-106 SPECIFIC DATA + WHC-SD-WM-ER-400
Release Height: Ground Level

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type			Release Duration		X/Qs	Release Type			Release Duration		X/Qs
		Steady State			> 3.6s		3.4E-2 s/m3	Steady State			> 420 s		1.9E-5 s/m3
		Puff			< 3.6s		9.8E-3/m3	Puff			< 420 s		4.1E-3/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide EPPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Antimony (Sb)	0.0E+00	0.0E+00	0.0E+00	2	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.5	0.0E+00	0.0E+00
Arsenic (As)	5.0E-02	2.0E+00	5.0E-01	0.1	2.0E+01	5.0E+00	1.1E-03	2.7E-03	0.01	1.1E-01	2.7E-04
Beryllium (Be)	2.8E-02	1.1E-01	2.8E-01	0.008	1.4E+02	4.0E+01	4.0E-04	1.0E-03	0.002	2.4E-01	6.0E-04
Cadmium (Cd)	7.7E-02	2.1E+00	7.7E-01	0.2	1.2E+01	3.8E+00	1.0E-03	3.0E-03	0.005	2.1E-01	6.0E-04
Cerium (Ce)	8.0E-01	3.1E+01	8.0E+00	70	4.4E-01	1.3E-01	1.7E-02	4.1E-02	2	8.8E-03	2.1E-03
Cobalt (Co)	1.4E-02	5.4E-01	1.4E-01	0.05	1.1E+01	3.2E+00	3.0E-04	7.3E-04	0.05	6.1E-03	1.7E-03
Cyanide	8.1E-02	3.3E+00	8.1E-01	5	1.5E-01	1.6E-01	1.0E-03	4.3E-03	5	2.1E-04	8.6E-07
Mercury (Hg)	8.5E-01	1.4E+01	5.1E+00	0.075	2.4E+02	6.8E+01	8.5E-03	2.3E-02	0.05	2.0E-01	4.7E-04
Neodymium (Nd)	2.3E-01	7.4E+00	2.3E+00	72	1.1E-01	3.2E-02	4.4E-04	1.2E-03	3.8	1.8E-03	3.5E-04
Oxalate	2.8E+02	9.4E+03	2.7E+03	4	2.3E+03	6.8E+02	5.0E+00	1.2E+02	1	5.2E+00	1.2E-02
TOC-Oxalate C	7.5E+01	2.0E+03	7.4E+02	3	8.5E+02	2.6E+02	1.4E+00	3.4E+00	2.5	6.7E-01	1.4E-03
Selenium (Se)	0.0E+00	0.0E+00	0.0E+00	0.2	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.2	0.0E+00	0.0E+00
Tellurium (Te)	2.0E-01	6.8E+00	2.0E+00	0.13	5.2E+01	1.5E+01	3.4E-03	9.0E-03	0.1	3.7E-02	9.0E-05
Thallium (Tl)	0.0E+00	0.0E+00	0.0E+00	0.3	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.1	0.0E+00	0.0E+00
Uranium (U)	5.8E-01	2.0E+01	5.8E+00	1	2.0E+01	5.8E+00	1.1E-02	2.8E-02	0.2	9.5E-02	1.3E-04
Vanadium (V)	1.9E-02	0.5E-01	1.9E-01	1.2	8.4E-01	1.0E-01	3.0E-04	8.0E-07	0.03	1.2E-02	2.5E-05
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	3.7E+03	1.1E+03	N/A	N/A	N/A	8.0E+00	1.7E-02
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	2.7E-04	9.3E-04	N/A	N/A	N/A	1.3E-01	6.2E+01

* In units of L/s for steady state releases and units of L for puff releases.
** Lower of PEL-TWA and EPPG-1 used for offsite risk guide

Table E-10B. Toxic Chemical Consequences — Unit Releases C-106 10-4 to 10-2 yr-1 Frequency - Toxics.

TABLE E-10B
Tank/Waste Type: C-106 SOLIDS
Frequency: 10-4 to 10-2 per year
Analyte type: Toxics

Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Chemical Inventory: C-106 SPECIFIC DATA + WHC-SD-WM-ER-400
Release Height: Ground Level

A	B	ONSITE (100 Meters)						OFFSITE (95th Boundary)					
		Release Type: Steady State Release / Puff		Release Duration: > 3.5s / < 3.5s		X/Q: 3.4E-2 s/m3 / 9.8E-3s/m3		Release Type: Steady State Release / Puff		Release Duration: > 420 s / < 420 s		X/Q: 1.8E-5 s/m3 / 4.9E-6s/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-2 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-1 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	0.0E+00	0.0E+00	0.0E+00	40	0.0E+00	0.0E+00		0.0E+00	0.0E+00	2	0.0E+00	0.0E+00	
Arsenic (As)	8.1E-02	2.9E+00	6.8E-01	7	2.9E-01	9.5E-02		1.1E-03	2.7E-03	0.1	1.1E-02	2.7E-03	
Beryllium (Be)	2.8E-02	8.7E-01	2.8E-01	0.005	3.8E+01	1.5E+01		4.4E-04	1.3E-03	0.005	8.1E-02	1.1E-04	
Cadmium (Cd)	7.7E-02	2.5E+00	7.6E-01	1	2.5E+00	7.5E-01		1.3E-03	3.5E-03	0.2	7.2E-03	1.7E-05	
Cerium (Ce)	0.0E-01	3.1E+01	8.1E+00	500	6.1E-02	1.8E-02		1.7E-02	4.1E-03	70	2.4E-04	5.8E-07	
Cobalt (Co)	1.0E-02	5.4E-01	1.6E-01	0.2	2.7E+00	7.8E-01		3.0E-04	7.2E-07	0.03	6.1E-03	1.4E-05	
Cyanide	0.0E-02	3.3E+00	9.5E-01	41	8.0E-02	2.3E-02		1.8E-03	4.1E-03	6	3.0E-04	6.9E-07	
Mercury (Hg)	5.9E-01	1.9E+01	5.1E+00	0.1	1.8E+02	5.1E+01		8.1E-03	2.3E-03	0.075	1.1E-01	3.1E-04	
Neodymium (Nd)	2.3E-01	7.6E+00	2.3E+00	594	1.6E-02	4.6E-03		4.4E-03	1.0E-03	78	6.1E-05	1.4E-07	
Oxalate	2.8E+02	9.4E+03	2.7E+03	20	4.7E+02	1.4E+02		5.9E+00	1.3E-02	4	1.3E+00	3.1E-03	
Oxide	7.5E+01	2.5E+03	7.4E+02	15	1.7E+02	5.0E+01		1.4E+00	3.4E-03	3	4.1E-01	1.1E-03	
TOC-Oxalate C	0.0E+00	0.0E+00	0.0E+00	0.4	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.2	0.0E+00	0.0E+00	
Selenium (Se)	0.0E-01	0.0E+00	0.0E+00	0.3	2.5E+01	6.5E+00		3.8E-03	8.0E-06	0.15	2.2E-02	4.7E-05	
Tellurium (Te)	0.0E+00	0.0E+00	0.0E+00	2	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.3	0.0E+00	0.0E+00	
Thallium (Tl)	5.8E-01	2.0E+01	5.8E+00	10	2.0E+00	5.8E-01		1.1E-02	2.5E-05	1	1.1E-02	2.5E-05	
Uranium (U)	1.9E-02	6.5E-01	1.9E-01	11	6.0E-02	1.7E-02		3.0E-04	8.0E-07	1.2	3.0E-04	7.1E-07	
Vanadium (V)		N/A	N/A	N/A	8.8E+02	2.8E+02		N/A	N/A	N/A	2.1E+00	4.9E-03	
SUM OF FRACTIONS		N/A	N/A	N/A	1.1E-03	3.0E-03		N/A	N/A	N/A	4.0E-01	2.0E+02	
ALLOWABLE RELEASE*		N/A	N/A	N/A									

* In units of L/s for steady state releases and units of L for puff releases.

Table E-10C. Toxic Chemical Consequences — Unit Releases C-106 10-4 to 10-6 yr-1 Frequency - Toxics.

TABLE 10C
Tank/Waste Type: C-106 SOLIDS
Frequency: 10-6 to 10-4 per year
Analyte type: Toxics

Toxic Chemical Consequences - Unit Release (Steady State - 1 L/s; Puff - 1 L)
Chemical Inventory: Inventory based on c-106 specific data + WHC-SD-WM-ER-400
Release Height: Ground Level

A	B	ONSITE (1001 Meters)						OFFSITE (8457 Boundary)					
		Release Type: Steady State Puff		Release Duration: > 3.5s / < 3.5s		X/Qs: 3.4E-2 s/m3 / 9.0E-3/m3		Release Type: Steady State Puff		Release Duration: > 420 s / < 420 s		X/Qs: 1.8E-5 s/m3 / 4.8E-6/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)	
Antimony (Sb)	0.0E+00	0.0E+00	0.0E+00	70	0.0E+00	0.0E+00		0.0E+00	0.0E+00	40	0.0E+00	0.0E+00	
Arsenic (As)	5.8E-02	2.0E+00	5.8E-01	40	5.0E-02	1.5E-02		1.1E-03	2.7E-06	7	1.6E-04	3.8E-07	
Beryllium (Be)	2.0E-02	6.7E-01	2.0E-01	0.1	6.7E+00	2.0E+00		4.0E-04	1.2E-04	0.025	1.6E-02	4.6E-05	
Cadmium (Cd)	7.7E-02	2.6E+00	7.6E-01	10	2.6E-01	7.6E-02		1.8E-03	3.8E-06	1	1.8E-03	3.8E-06	
Cerium (Ce)	9.0E-01	3.1E+01	8.8E+00	700	4.4E-02	1.3E-02		1.7E-02	4.1E-05	600	3.4E-05	8.1E-08	
Cobalt (Co)	1.6E-02	5.4E-01	1.6E-01	6	8.0E-02	2.0E-02		3.0E-04	7.4E-07	0.2	1.8E-03	3.6E-06	
Cyanide	9.6E-02	3.3E+00	9.5E-01	200	1.6E-02	4.8E-03		1.8E-03	4.5E-06	41	4.4E-05	1.1E-07	
Mercury (Hg)	5.2E-01	1.8E+01	5.1E+00	14	1.3E+00	3.7E-01		8.0E-03	2.8E-05	0.1	0.8E-02	2.8E-04	
Neodymium (Nd)	2.3E-01	7.9E+00	2.3E+00	720	1.1E-02	3.2E-03		4.4E-03	1.0E-05	504	8.7E-06	2.1E-08	
Oxalate	2.8E+02	9.4E+03	2.7E+03	40	2.3E+02	6.8E+01		5.5E+00	1.3E-02	20	2.8E-01	6.8E-04	
TOC-Oxalate C	7.5E+01	2.6E+03	7.4E+02	50	5.1E+01	1.5E+01		1.4E+00	3.4E-03	15	9.6E-02	2.3E-04	
Selenium (Se)	0.0E+00	0.0E+00	0.0E+00	2	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.4	0.0E+00	0.0E+00	
Tellurium (Te)	2.0E-01	6.8E+00	2.0E+00	1.4	4.8E+00	1.4E+00		3.3E-03	9.0E-06	0.3	1.3E-02	3.0E-05	
Thallium (Tl)	0.0E+00	0.0E+00	0.0E+00	20	0.0E+00	0.0E+00		0.0E+00	0.0E+00	2	0.0E+00	0.0E+00	
Uranium (U)	5.9E-01	2.0E+01	5.8E+00	20	8.9E-01	2.6E-01		1.1E-02	2.6E-05	10	1.1E-03	2.6E-06	
Vanadium (V)	1.9E-02	6.5E-01	1.9E-01	40	1.8E-02	4.7E-03		3.6E-04	8.6E-07	11	3.5E-05	7.8E-06	
SUM OF FRACTIONS		N/A	N/A	N/A	3.0E+02	8.6E+01		N/A	N/A	N/A	4.9E-01	1.2E-03	
ALLOWABLE RELEASE*		N/A	N/A	N/A	3.3E-03	1.1E-02		N/A	N/A	N/A	2.0E+00	8.0E+02	

* In units of L/s for steady state releases and units of L for puff releases.

Table E-10D. Toxic Chemical Consequences — Unit Releases C-106
10-2 to 1 yr-1 Frequency - Corrosives.

TABLE 10D — Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: C-106 SOLIDS — Chemical Inventory: — 100% bounding per KEH inventory data
Frequency: 10-2 to 10-0 per year — Release Height: — Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)							OFFSITE (site boundary)					
		Release Type: Steady State Puff		Release Duration: > 3.5s / < 3.5s			χ/Q: 3.4E-2 s/m3 / 9.0E-3s/m3		Release Type: Steady State Puff		Release Duration: > 420 s / < 420 s		χ/Q: 1.9E-5 s/m3 / 4.1E-4s/m3	
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)-s	E Risk Guide ERPG-1 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)	H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)-s	J Risk Guide** PEL-TWA (mg/m3)	K Fraction of Risk Guide Steady State (unitless)	L Fraction of Risk Guide Puff (unitless)
Ammonia (NH3)	3.3E-01	1.1E+01	3.3E+00	0.46	2.4E+01	7.1E+00	6.3E-03	1.8E-06	0.46	1.2E-02	3.9E-06
Barium (Ba)	7.8E+00	2.7E+02	7.7E+01	0.5	5.1E+01	1.1E+01	1.0E-01	3.1E-04	0.5	3.0E-01	7.0E-04
Calcium (Ca)	1.8E+01	6.0E+02	1.8E+02	1	0.0E+02	1.8E+02	3.9E-01	0.0E-04	1	3.9E-01	6.8E-04
Chromium (Cr+3)	2.8E+00	9.8E+01	2.8E+01	2.8	3.5E+01	9.8E+00	4.4E-02	1.1E-04	0.8	8.8E-01	2.3E-04
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	50	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.2	0.0E+00	0.0E+00
Lanthanum (La)	5.0E+01	1.7E+03	5.0E+02	0.9	2.8E+02	7.2E+01	0.8E-01	2.5E-03	0.9	1.4E-01	3.8E-04
Sodium (Na - NaOH)	4.6E+01	1.6E+03	4.6E+02	1.2	1.3E+03	3.9E+02	0.7E-01	2.1E-03	1.2	7.3E-01	1.7E-03
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	2	3.6E+03	1.0E+03	4.0E+00	9.8E-03	2	2.0E+00	4.7E-03
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	6.0E+03	1.7E+03	N/A	N/A	N/A	5.0E+00	1.1E-03
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	1.7E-04	5.9E-04	N/A	N/A	N/A	2.0E-01	1.2E+02

* In units of L/s for steady state release and units of L for puff release.
** lower of PEL-TWA and ERPG-1 are used for offsite calculation

Table E-10E. Toxic Chemical Consequences — Unit Releases C-106
10-4 to 10-2 yr-1 Frequency - Corrosives.

TABLE 10E Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)

Tank/Waste Type: C-106 Chemical Inventory: C-106 SPECIFIC DATA + WHC-SD-WM-ER-400

Frequency: 10-4 to 10-2 per year Release Height: Ground Level

Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)					OFFSITE (Site Boundary)				
		Release Type		Release Duration		X/Qs	Release Type		Release Duration		X/Qs
		Steady State		> 3.5s		3.4E-2 s/m3	Steady State		> 420 s		1.9E-5 s/m3
		Puff		< 3.5s		9.9E-3/m3	Puff		< 420 s		4.5E-8/m3
		C	D	E	F	G	H	I	J	K	L
Analyte	Analyte Concentration (g/L)	Steady State Release Consequence (mg/m3)	Puff Release Consequence (mg/m3)	Risk Guide ERPG-2 (mg/m3)	Fraction of Risk Guide Steady State (unitless)	Fraction of Risk Guide Puff (unitless)	Steady State Release Consequence (mg/m3)	Puff Release Consequence (mg/m3)	Risk Guide ERPG-1 (mg/m3)	Fraction of Risk Guide Steady State (unitless)	Fraction of Risk Guide Puff (unitless)
Ammonia (NH3)	3.3E-01	1.1E+01	3.3E+00	9.2	1.2E+00	3.6E-01	6.3E-03	1.9E-05	0.46	1.4E-02	3.9E-05
Barium (Ba)	7.8E+00	2.7E+02	7.7E+01	138	1.9E+00	5.6E-01	1.5E-01	3.5E-04	6.8	2.2E-02	5.2E-05
Calcium (Ca)	1.9E+01	6.5E+02	1.9E+02	22	2.9E+01	8.6E+00	3.6E-01	8.6E-04	1	3.6E-01	8.6E-04
Chromium (Cr+3)	2.5E+00	8.5E+01	2.5E+01	51.5	1.7E+00	4.9E-01	4.6E-02	1.1E-04	2.6	1.8E-02	4.3E-05
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	600	0.0E+00	0.0E+00	0.0E+00	0.0E+00	80	0.0E+00	0.0E+00
Lanthanum (La)	5.0E+01	1.7E+03	5.0E+02	137	1.2E+01	3.6E+00	9.5E-01	2.3E-03	6.9	1.4E-01	3.3E-04
Sodium (Na - NaOH)	4.5E+01	1.5E+03	4.5E+02	23	6.7E+01	1.9E+01	8.6E-01	2.0E-03	1.2	7.1E-01	1.7E-03
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	40	1.8E+02	5.2E+01	4.0E+00	9.8E-03	2	2.0E+00	4.7E-03
SUM OF FRACTIONS	N/A	N/A	N/A	N/A	2.9E+02	8.5E+01	N/A	N/A	N/A	3.3E+00	7.7E-03
ALLOWABLE RELEASE*	N/A	N/A	N/A	N/A	3.4E-03	1.2E-02	N/A	N/A	N/A	3.1E-01	1.3E+02

* In units of L/s for steady state releases and units of L for puff releases.

Table E-10F. Toxic Chemical Consequences — Unit Releases C-106
10-6 to 10-4 yr-1 Frequency - Corrosives.

TABLE E-10F Toxic Chemical Consequences - Unit Releases (Steady State - 1 L/s; Puff - 1 L)
Tank/Waste Type: C-106 Chemical Inventory: C-106 specific data + WHC-SD-WM-ER-400
Frequency: 10-6 to 10-4 per year Release Height: Ground Level
Analyte type: Corrosives/Irritants

A	B	ONSITE (100 Meters)						OFFSITE (Site Boundary)					
		Release Type: Steady State Puff; Release Duration: > 3.5s / < 3.5s				X/Qs: 3.4E-2 s/m3 / 9.9E-3/m3		Release Type: Steady State Puff		Release Duration: > 420 s / < 420 s			X/Qs: 1.8E-5 s/m3 / 4.8E-6/m3
Analyte	Analyte Concentration (g/L)	C Steady State Release Consequence (mg/m3)	D Puff Release Consequence (mg/m3)	E Risk Guide ERPG-3 (mg/m3)	F Fraction of Risk Guide Steady State (unitless)	G Fraction of Risk Guide Puff (unitless)		H Steady State Release Consequence (mg/m3)	I Puff Release Consequence (mg/m3)	J Risk Guide ERPG-2 (mg/m3)	K Fraction of Risk Guide Steady State (unitless)		L Fraction of Risk Guide Puff (unitless)
Ammonia (NH3)	3.5E-01	1.1E+01	3.3E+00	29	4.1E-01	1.7E-01		1.5E-03	1.5E-03	6.3	1.6E-04		1.6E-05
Barium (Ba)	7.8E+00	2.7E+02	7.7E+01	344	7.7E-01	2.2E-01		1.1E-01	3.0E-04	150	1.1E-03		2.2E-05
Calcium (Ca)	1.5E+01	5.0E+02	1.5E+02	64	1.2E+01	3.1E+00		3.0E-01	8.0E-04	22	1.6E-02		3.1E-05
Chromium (Cr+3)	2.6E+00	8.5E+01	2.5E+01	129	6.6E-01	1.3E-01		4.4E-02	1.1E-04	61.5	9.3E-04		2.2E-05
Dysprosium (Dy)	0.0E+00	0.0E+00	0.0E+00	800	0.0E+00	0.0E+00		0.0E+00	0.0E+00	400	0.0E+00		0.0E+00
Lanthanum (La)	5.0E+01	1.7E+03	5.0E+02	343	5.0E+00	1.4E+00		8.8E-01	2.5E-03	157	6.8E-03		1.4E-05
Sodium (Na - NaOH)	4.6E+01	1.6E+03	4.6E+02	58	2.7E+01	7.9E+00		0.7E-01	2.1E-03	23	3.1E-02		8.0E-05
Sod. Hydroxide (NaOH)	2.1E+02	7.1E+03	2.1E+03	100	7.1E+01	2.1E+01		4.0E+00	9.8E-03	40	1.0E-01		2.4E-04
SUM OF FRACTIONS		N/A	N/A	N/A	1.2E+02	3.4E+01		N/A	N/A	N/A	1.2E-01		3.1E-04
ALLOWABLE RELEASE*		N/A	N/A	N/A	8.5E-03	2.9E-02		N/A	N/A	N/A	8.1E+00		2.6E+03

* In units of L/s for steady state releases and units of L for puff release.

Table E-11. Particulate Constants For Tank Farm Composites.

Source material	Type of release	Receptor	Constant for 1 to 10-2 frequency*	Constant for 10-2 to 10-4 frequency*	Constant for 10-4 to 10-6 frequency*
DST and SST liquids	Continuous	Onsite	1.3 E+03	7.5 E+02	7.5 E+01
		Offsite	2.1 E+00	7.0 E-01	4.2 E-01
DST and SST solids	Continuous	Onsite	1.8 E+03	1.1 E+03	1.1 E+02
		Offsite	3.0 E+00	1.0 E+00	6.1 E-01
DST and SST liquids	Puff	Onsite	3.6 E+02	2.2 E+02	2.2 E+01
		Offsite	5.0 E-03	1.7 E-03	9.9 E-04
DST and SST solids	Puff	Onsite	5.3 E+02	3.2 E+02	3.2 E+01
		Offsite	7.2 E-03	2.4 E-03	1.4 E-03
50% NaOH	Continuous	Onsite	1.7 E+03	1.0 E+03	1.0 E+02
		Offsite	2.9 E+00	9.6 E-01	5.8 E-01
50% NaOH	Puff	Onsite	5.0 E+02	3.0 E+02	3.0 E+01
		Offsite	6.8 E-03	2.3 E-03	1.4 E-03

*Constant is based on a unit liter release for puff and a 1 liter/s release for a continuous release similar to toxic and corrosive releases. The constant is given by:

$$C = (\rho \times 10^6 \times Q' \times \chi/Q)/RG$$

where

C = Constant given in Table
Q' = Release amount (L/s)
χ/Q' = Puff atmospheric dispersion coefficient (s/m^3)
ρ = Density of source material.
RG = Risk guideline

The guidelines for particulates are

- ERPG-3 = 500 mg/m^3
- ERPG-2 = 50 mg/m^3
- ERPG-1 = 30 mg/m^3
- PEL-TWA = 10 mg/m^3

The guidelines to be used depend on the accident frequency class and location of the maximum onsite/offsite individual. See the discussion in Section 3.5. ρ for solids is 1.6 g/cm^3, 1.1 g/cm^3 for liquids, and 1.52 g/cm^3 for the 50% NaOH.

Table E-12 Summary of Chemical Release Sum of Fractions.

Sum of fractions taken from Tables E-1A through E-11

E-12A SST Tanks Continuous Release

Material	Receptor	Frequency	Particulate Constant	Toxic Constant	Corrosive Constant
LIQUID	ONSITE	10-2 TO 1	1.3 E+03	7.2 E+02	9.6 E+03*
		10-4 TO 10-2	7.5 E+02*	2.2 E+02	4.9 E+02
		10-6 TO 10-4	7.5 E+01	3.4 E+01	2.0 E+02*
	OFFSITE	10-2 TO 1	2.1 E+00	8.4 E-01	5.4 E+00*
		10-4 TO 10-2	7.0 E-01	4.0 E-01	5.4 E+00*
		10-6 TO 10-4	4.2 E-01*	1.2 E-01	2.8 E-01
SOLID	ONSITE	10-2 TO 1	1.8 E+03	3.9 E+04*	2.0 E+04
		10-4 TO 10-2	1.1 E+03	2.0 E+04*	1.0 E+03
		10-6 TO 10-4	1.1 E+02	9.8 E+02*	4.1 E+02
	OFFSITE	10-2 TO 1	3.0 E+00	6.3 E+01*	1.5 E+01
		10-4 TO 10-2	1.0 E+00	2.2 E+01*	1.1 E+01
		10-6 TO 10-4	6.1 E-01	1.1 E+01*	5.8 E-01

* Largest of particulate, toxic, and corrosive sum of fractions for this composite, receptor, and frequency bin.

E-12B SST Tanks Puff Release

Material	Receptor	Frequency	Particulate Constant	Toxic Constant	Corrosive Constant
LIQUID	ONSITE	10-2 TO 1	3.6 E+02	2.1 E+02	2.8 E+03*
		10-4 TO 10-2	2.2 E+02*	6.3 E+01	1.4 E+02
		10-6 TO 10-4	2.2 E+01	9.8 E+00	5.7 E+01*
	OFFSITE	10-2 TO 1	5.0 E-03	2.0 E-03	1.3 E-02*
		10-4 TO 10-2	1.7 E-03	9.5 E-04	1.3 E-02*
		10-6 TO 10-4	9.9 E-04*	2.9 E-04	6.5 E-04
SOLID	ONSITE	10-2 TO 1	5.3 E+02	1.1 E+04*	5.9 E+03
		10-4 TO 10-2	3.2 E+02	6.0 E+03*	3.0 E+02
		10-6 TO 10-4	3.2 E+01	2.9 E+02*	1.2 E+02
	OFFSITE	10-2 TO 1	7.2 E-03	1.5 E-01*	3.5 E-02
		10-4 TO 10-2	2.4 E-03	5.2 E-02*	2.7 E-02
		10-6 TO 10-4	1.4 E-03	2.7 E-02*	1.4 E-03

* Largest of particulate, toxic, and corrosive sum of fractions for this composite, receptor, and frequency bin.

E-12C DST Tanks Continuous Release

Material	Receptor	Frequency	Particulate Constant	Toxic Constant	Corrosive Constant
LIQUID	ONSITE	10-2 TO 1	1.3 E+03	9.2 E+02	1.0 E+04*
		10-4 TO 10-2	7.5 E+02*	1.6 E+02	5.2 E+02
		10-6 TO 10-4	7.5 E+01	5.2 E+01	2.1 E+02*
	OFFSITE	10-2 TO 1	2.1 E-00	1.7 E+00	5.6 E+00*
		10-4 TO 10-2	7.0 E-01	5.2 E-01	5.6 E+00*
		10-6 TO 10-4	4.2 E-01*	9.1 E-02	2.9 E-01
SOLID	ONSITE	10-2 TO 1	1.8 E+03	1.4 E+04	1.7 E+04*
		10-4 TO 10-2	1.1 E+03	2.4 E+03*	8.7 E+02
		10-6 TO 10-4	1.1 E+02	5.6 E+02*	3.5 E+02
	OFFSITE	10-2 TO 1	3.0 E-00	1.3 E+02*	1.4 E+01
		10-4 TO 10-2	1.0 E+00	8.0 E+00	9.5 E+00*
		10-6 TO 10-4	6.1 E-01	1.4 E+00*	4.9 E-01

* Largest of particulate, toxic, and corrosive sum of fractions for this composite, receptor, and frequency bin.

E-12D DST Tanks Puff Release

Material	Receptor	Frequency	Particulate Constant	Toxic Constant	Corrosive Constant
LIQUID	ONSITE	10-2 TO 1	3.6 E+02	2.7 E+02	2.9 E+03*
		10-4 TO 10-2	2.2 E+02*	4.7 E+01	1.5 E+02
		10-6 TO 10-4	2.2 E+01	1.5 E+01	6.0 E+01*
	OFFSITE	10-2 TO 1	5.0 E-03	4.0 E-03	1.3 E-02*
		10-4 TO 10-2	1.7 E-03	1.2 E-03	1.3 E-02*
		10-6 TO 10-4	9.9 E-04*	2.1 E-04	6.8 E-04
SOLID	ONSITE	10-2 TO 1	5.3 E+02	4.2 E+03	5.0 E+03*
		10-4 TO 10-2	3.2 E+02	7.1 E+02*	2.5 E+02
		10-6 TO 10-4	3.2 E+01	1.6 E+02*	1.0 E+02
	OFFSITE	10-2 TO 1	7.2 E-03	3.0 E-01*	3.4 E-02
		10-4 TO 10-2	2.4 E-03	1.9 E-02	2.3 E-02*
		10-6 TO 10-4	1.4 E-03	3.2 E-03*	1.2 E-03

* Largest of particulate, toxic, and corrosive sum of fractions for this composite, receptor, and frequency bin.

E-12E - Headspace Gas Release

Release Type	Receptor	Frequency	Central Nervous System Constant	Systemic Poison Constant	Corrosive and Irritant Constant
Gas Concentrations based worst case data (includes slurry gas release)					
CONTINUOUS	ONSITE	10-2 TO 1	1.4 E+01	3.5 E-01	7.7 E+01*
		10-4 TO 10-2	2.3 E-01	5.3 E-02	9.4 E+00*
		10-6 TO 10-4	1.1 E-01	1.8 E-02	1.9 E+00*
	OFFSITE	10-2 TO 1	2.4 E-02	2.0 E-04	4.5 E-02*
		10-4 TO 10-2	8.3 E-03	2.0 E-04	4.5 E-02*
		10-6 TO 10-4	1.3 E-04	3.1 E-05	5.4 E-03*
PUFF	ONSITE	10-2 TO 1	4.3 E+00	1.1 E-01	2.3 E+01*
		10-4 TO 10-2	6.8 E-02	1.6 E-02	2.8 E+00*
		10-6 TO 10-4	3.2 E-02	5.3 E-03	5.8 E-01*
	OFFSITE	10-2 TO 1	5.7 E-05	4.8 E-07	1.1 E-04*
		10-4 TO 10-2	2.0 E-05	4.8 E-07	1.1 E-04*
		10-6 TO 10-4	3.1 E-07	7.3 E-08	1.3 E-05*
Gas concentration based on maximum steady state sample data (does not include slurry gases					
CONTINUOUS	ONSITE	10-2 TO 1	9.7 E-01	3.5 E-01	2.6 E+00*
		10-4 TO 10-2	2.7 E-02	5.3 E-02	3.3 E-01*
		10-6 TO 10-4	6.0 E-03	1.8 E-02	7.1 E-02*
	OFFSITE	10-2 TO 1	9.0 E-04	2.0 E-04	1.5 E-03*
		10-4 TO 10-2	5.6 E-04	2.0 E-04	1.5 E-03*
		10-6 TO 10-4	1.6 E-05	3.1 E-05	1.9 E-04*
PUFF	ONSITE	10-2 TO 1	2.9 E-01	1.1 E-01	7.9 E-01*
		10-4 TO 10-2	8.1 E-03	1.6 E-02	9.9 E-02*
		10-6 TO 10-4	1.8 E-03	5.3 E-03	2.1 E-02*
	OFFSITE	10-2 TO 1	2.1 E-06	4.8 E-07	3.7 E-06*
		10-4 TO 10-2	1.3 E-06	4.8 E-07	3.6 E-06*
		10-6 TO 10-4	3.7 E-08	7.3 E-08	4.5 E-07*

* Largest of central nervous system, systemic poison, or corrosive sum of fractions for this composite, receptor, and frequency bin.

E-12F Flammable Gas Watchlist Liquid and Solids Composite Release

Release Type	Receptor	Frequency	Particulate Constant	Toxic Constant	Corrosive Constant
CONTINUOUS	ONSITE	10-2 TO 1	1.8 E+03	5.8 E+03	1.3 E+04*
		10-4 TO 10-2	1.1 E+03*	9.9 E+02	6.6 E+02
		10-6 TO 10-4	1.1 E+02	2.3 E+02	2.6 E+02*
	OFFSITE	10-2 TO 1	3.0 E+00	1.4 E+01*	8.0 E+00
		10-4 TO 10-2	1.0 E+00	3.2 E+00	7.2 E+00*
		10-6 TO 10-4	6.1 E-01*	5.5 E-01	3.7 E-01
PUFF	ONSITE	10-2 TO 1	5.3 E+02	1.7 E+03	3.7 E+03*
		10-4 TO 10-2	3.2 E+02*	2.9 E+02	1.9 E+02
		10-6 TO 10-4	3.2 E+01	6.7 E+01	7.7 E+01*
	OFFSITE	10-2 TO 1	7.2 E-03	3.4 E-02*	1.9 E-02
		10-4 TO 10-2	2.4 E-03	7.6 E-03	1.7 E-02*
		10-6 TO 10-4	1.4 E-03*	1.3 E-03	8.7 E-04

* Largest of particulate, toxic, and corrosive sum of fractions for this composite, receptor, and frequency bin.

E-12G 50% NaOH Solution Continuous Release

Release Type	Receptor	Frequency	Particulate Constant	Toxic Constant	Corrosive Constant
CONTINUOUS	ONSITE	10-2 TO 1	1.7 E+03	0.0 E+00	1.3 E+04*
		10-4 TO 10-2	1.0 E+03*	0.0 E+00	6.5 E+02
		10-6 TO 10-4	1.0 E+02	0.0 E+00	2.6 E+02*
	OFFSITE	10-2 TO 1	2.9 E+00	0.0 E+00	7.2 E+00*
		10-4 TO 10-2	9.6 E-01	0.0 E+00	7.2 E+00*
		10-6 TO 10-4	5.8 E-01*	0.0 E-00	3.6 E-01
PUFF	ONSITE	10-2 TO 1	5.0 E+02	0.0 E+00	3.8 E+03*
		10-4 TO 10-2	3.0 E+02*	0.0 E+00	1.9 E+02
		10-6 TO 10-4	3.0 E+01	0.0 E+00	7.5 E+01*
	OFFSITE	10-2 TO 1	6.8 E-03	0.0 E-00	1.7 E-02*
		10-4 TO 10-2	2.3 E-03	0.0 E-00	1.7 E-02*
		10-6 TO 10-4	1.4 E-03*	0.0 E-00	8.6 E-04

* Largest of particulate, toxic, and corrosive sum of fractions for this composite, receptor, and frequency bin.

E-12H All Liquids and All Solids Continuous Release

Material	Receptor	Frequency	Particulate Constant	Toxic Constant	Corrosive Constant
LIQUID	ONSITE	10-2 TO 1	1.3 E+03	1.1 E+03	1.0 E+04*
		10-4 TO 10-2	7.5 E+02*	2.7 E+02	5.2 E+02
		10-6 TO 10-4	7.5 E+01	5.4 E+01	2.1 E+02*
	OFFSITE	10-2 TO 1	2.1 E+00	1.9 E+00	5.6 E+00*
		10-4 TO 10-2	7.0 E-01	6.1 E-01	5.6 E+00*
		10-6 TO 10-4	4.2 E-01*	1.5 E-01	2.9 E-01
SOLID	ONSITE	10-2 TO 1	1.8 E+03	4.8 E+04*	2.2 E+04
		10-4 TO 10-2	1.1 E+03	2.2 E+04*	1.1 E+03
		10-6 TO 10-4	1.1 E+02	1.2 E+03*	4.5 E+02
	OFFSITE	10-2 TO 1	3.0 E+00	1.7 E+02*	1.8 E+01
		10-4 TO 10-2	1.0 E+00	2.7 E+01*	1.2 E+01
		10-6 TO 10-4	6.1 E-01	1.2 E+01*	6.3 E-01

* Largest of particulate, toxic, and corrosive sum of fractions for this composite, receptor, and frequency bin.

E-12I All Liquids and Solids Puff Release

Material	Receptor	Frequency	Particulate Constant	Toxic Constant	Corrosive Constant
LIQUID	ONSITE	10-2 TO 1	3.6 E+02	3.2 E+02	2.9 E+03*
		10-4 TO 10-2	2.2 E+02*	7.9 E+01	1.5 E+02
		10-6 TO 10-4	2.2 E+01	1.6 E+01	6.0 E+01*
	OFFSITE	10-2 TO 1	5.0 E-03	4.4 E-03	1.3 E-02*
		10-4 TO 10-2	1.7 E-03	1.5 E-03	1.3 E-02*
		10-6 TO 10-4	9.9 E-04*	3.6 E-04	6.8 E-04
SOLID	ONSITE	10-2 TO 1	5.3 E+02	1.4 E+04*	6.4 E+03
		10-4 TO 10-2	3.2 E+02	6.4 E+03*	3.3 E+02
		10-6 TO 10-4	3.2 E+01	3.4 E+02*	1.3 E+02
	OFFSITE	10-2 TO 1	7.2 E-03	4.0 E-01*	4.4 E-02
		10-4 TO 10-2	2.4 E-03	6.3 E-02*	2.9 E-02
		10-6 TO 10-4	1.4 E-03	2.9 E-02*	1.5 E-03

* Largest of particulate, toxic, and corrosive sum of fractions for this composite, receptor, and frequency bin.

E-12J C-106 Solids Continuous Release

Release Type	Receptor	Frequency	Particulate Constant	Toxic Constant	Corrosive Constant
CONTINUOUS	ONSITE	10-2 TO 1	1.8 E+03	3.7 E+03	5.9 E+03*
		10-4 TO 10-2	1.1 E+03*	8.8 E+02	2.9 E+02
		10-6 TO 10-4	1.1 E+02	3.0 E+02*	1.2 E+02
	OFFSITE	10-2 TO 1	3.0 E+00	6.8 E+00*	3.6 E+00
		10-4 TO 10-2	1.0 E+00	2.1 E+00	3.3 E+00*
		10-6 TO 10-4	6.1 E-01*	4.9 E-01	1.6 E-01
PUFF	ONSITE	10-2 TO 1	5.3 E+02	1.1 E+03	1.7 E+03*
		10-4 TO 10-2	3.2 E+02*	2.6 E+02	8.5 E+01
		10-6 TO 10-4	3.2 E+01	8.8 E+01*	3.4 E+01
	OFFSITE	10-2 TO 1	7.2 E-03	1.6 E-02*	8.6 E-03
		10-4 TO 10-2	2.4 E-03	4.9 E-03	7.7 E-03*
		10-6 TO 10-4	1.4 E-03*	1.2 E-03	3.9 E-04

* Largest of particulate, toxic, and corrosive sum of fractions for this composite, receptor, and frequency bin.

PEER REVIEW CHECKLIST

Document Reviewed: Toxic Chemical Considerations for Tank Farm Releases, Revision 1, WHC-SD-WM-SARR-011
Author: J. C. Van Keuren, J. S. Davis, M. L. Dentler
Date: October 1995
Scope of Review: Entire Document. The review focussed on the text and the generation of the sum of fraction values. The following appendices were peer reviewed by other individuals who were knowledgeable in the subject area contained in that appendix: Appendix A, Appendix B and Appendix D.

Yes	No	NA	
[✓]	[ ]	[ ]	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
[✓]	[ ]	[ ]	Problem completely defined.
[ ]	[ ]	[✓]	Accident scenarios developed in a clear and logical manner.
[✓]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[ ]	[ ]	[✓]	Computer codes and data files documented.
[✓]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[✓]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[✓]	[ ]	[ ]	Mathematical derivations checked including dimensional consistency of results.
[✓]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
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[✓]	[ ]	[ ]	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[✓]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[✓]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[✓]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[ ]	[ ]	[✓]	Format consistent with appropriate NRC Regulatory Guide or other standards
[ ]	[ ]	[✓]	Review calculations, comments, and/or notes are attached.
[✓]	[ ]	[ ]	Document approved.

Anthony V. Savino / Anthony V. Savino — 10/28/95
Reviewer (Printed Name and Signature) — Date

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Author: J. C. Van Keuren, J. S. Davis, M. L. Dentler
Date: October 1995
Scope of Review: Entire Document

YES	NO*	N/A		
[✓]	[ ]	[ ]	1.	A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
[ ]	[ ]	[✓]	2.	Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
[✓]	[ ]	[ ]	3.	HEDOP-approved code(s) were used.
[ ]	[ ]	[✓]	4.	Receptor locations were selected according to HEDOP recommendations.
[✓]	[ ]	[ ]	5.	All applicable environmental pathways and code options were included and are appropriate for the calculations.
[✓]	[ ]	[ ]	6.	Hanford site data were used.
[ ]	[ ]	[✓]	7.	Model adjustments external to the computer program were justified and performed correctly.
[✓]	[ ]	[ ]	8.	The analysis is consistent with HEDOP recommendations.
[ ]		[✓]	9.	Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)
[✓]	[ ]		10.	Approval is granted on behalf of the Hanford Environmental Dose Overview Panel.

* All "NO" responses must be explained and use of nonstandard methods justified.

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WHC-SD-WM-SARR-011, Rev 1, Toxic Chemical Considerations for Tank Farm Releases		ECN No. 165782

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Title/Desc:
TOXIC CHEMICAL CONSIDERATIONS FOR TFARM RELEASES [SEC 1 OF 2]

Pages: 146

This document was too large to scan as a whole document, therefore it required breaking into smaller sections.

DOCUMENT NUMBER: WM-SARR-011

SECTION 1 OF 2

TITLE: Tank Farm Accelerated Safety

DATE: 11/20/95

ORIGINATOR: G A Chaffee

CO:

RECIPIENT:

CO:

REFERENCES:

COMPLETE

ENGINEERING CHANGE NOTICE

Page 1 of XX

1. ECN 165782

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	3a. USQ Required?	4. Date
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12. Description of Change

This document revision describes the method utilized in WHC-SD-WM-SAR-065, Tank Farm Hazard and Accident Analysis Potential for Releases Requiring Mitigation and Prevention. A determination was made of the most restrictive toxic chemicals that are expected to be present in the tanks. A sum of fractions of the health effects was computed for each composite for unit releases based on emergency response planning guidelines (ERPGs). The calculation method in this report was applied to actual release scenarios by multiplying the sum of fractions by the release rate for continuous releases, or the release amount of puff releases.

13a. Justification (mark one)

Criteria Change	[X]	Design Improvement	[]	Environmental	[]	Facility Deactivation	[]
As-Found	[]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

13b. Justification Details

This revision is being made to be consistent with the technical work performed on the methodology and its application in determining the toxicological consequences of accidental releases from the Hanford Tank Farms as currently applied in WHC-SD-WM-SAR-065

14. Distribution (include name, MSIN, and no. of copies)

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18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 12. Enter the affected document number in Block 19.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR/ISB	[X]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

19. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision

20. Approvals

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OPERATIONS AND ENGINEERING		ARCHITECT-ENGINEER	
Cog. Eng. J.C. Van Keuren J C Van Keuren	Nov 14, 1995	PE	
Cog. Mgr. D. S. Leach D.S. Leach	11/14/95	QA	
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7. Abstract

This document provides a method of determining the toxicological consequences of accidental releases from Hanford Tank Farms. A determination was made of the most restrictive toxic chemicals that are expected to be present in the tanks. Concentrations were estimated based on the maximum sample data for each analyte in all the tanks in the composite. Composite evaluated were liquids and solids from single shell tanks, double shell tank, flammable gas watch list tanks, as well as all solids, all liquids, head space gases, and 241-C-106 solids. A sum of fractions of the health effects was computed for each composite for unit releases based emergency response planning guidelines (ERPGs). Where ERPGS were not available for chemical compounds of interest, surrogate guidelines were established. The calculation method in this report can be applied to actual release scenarios by multiplying the sum of fractions by the release rate for continuous releases, or the release amount for puff releases. Risk guidelines are met if the product is less than or equal to one.

8. RELEASE STAMP

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TOXIC CHEMICAL CONSIDERATIONS FOR TANK FARM RELEASES

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Revision 1

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LIST OF TERMS

ACGIH	American Conference of Governmental Industrial Hygienists Guidelines
AIHA	American Industrial Hygiene Association
ARF	airborne release fraction
DOE-RL	U.S. Department of Energy-Richland Field Offices
DST	double-shell tank
EPA	U.S. Environmental Protection Agency
ERPG	emergency response planning guideline
HEHF	Hanford Environmental Health Foundation
M&O	management and operating
NRCCOT	National Research Council's Committee on Toxicology
PEL-TWA	permissible exposure limit - time weighted average
RF	respirable fraction
SST	single-shell tank
TRAC	track radioactive component

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TOXIC CHEMICAL CONSIDERATIONS FOR TANK FARM RELEASES

1.0 PURPOSE

The purpose of this topical report is to document the methodology developed to compare the consequences of chemical and gaseous releases against risk acceptance criteria.

2.0 SCOPE

The scope of this document includes four major areas:

1. The methods used to determine what chemicals might be present in the tanks and determine which of these might be toxic.

2. The methods used to determine the bounding composition of each analyte.

3. The methods used to develop risk acceptance criteria for toxic releases.

4. The methods used to determine release concentrations and to compare these concentrations against risk acceptance criteria.

The approach used for these analyses are contained in the following sections and supporting documents are furnished in Appendices. This document contains the methods to be used for comparison to risk acceptance criteria, not the comparison itself. All calculations are based on a release of 1 liter for puff releases, and a 1 liter/second release rate for continuous releases. The actual comparison to risk acceptance criteria are performed by multiplying the scenario dependent release amount or release rates by the sum of fraction constant derived in this report. An application of this method is given in SARR-065.

3.0 METHODOLOGY

The toxic chemical exposure effects were evaluated for comparison against the safety analysis risk acceptance guidelines from WHC-CM-4-46. This required an estimation of the toxic chemical concentrations at the maximum onsite and offsite individual locations as a result of releases.

The toxicological source terms for the tank farm accidents consist of liquid and solid particulates, and gases. Evaluation of the effects of chemical exposure has been conducted only for the airborne pathway. Exposure

limits are based on the inhalation pathway. Exposure to skin and the eyes is considered in the development of the limits for corrosives and irritants, but inhalation is the dominant pathway.

Particles transported to the maximum onsite/offsite individual are assumed to be respirable, with airborne release fractions (ARFs) and respirable fractions (RFs) determined by data specific to the accident scenario. Concentrations at the maximum onsite/offsite individual are computed using a Gaussian plume model for particles and gases. All material reaching the lung is assumed to be retained in the body.

The other potential internal exposure pathway is the ingestion pathway. Ingestion of chemicals could occur from consuming crops or animals that have been exposed to the chemicals. Potential chemical exposures from the ingestion pathway are not included because there are federal and state programs to prevent ingestion of contaminated food (DOE 1994, WSDOH 1993, WS 1994, EPA 1992). This approach is consistent with the approach taken for radioactive exposures described in SARR-016 (SARR-016).

In evaluating the consequences of accidental releases of chemicals from the tanks, the chemicals were divided into three categories:

- Total particulates
- Corrosives and irritants
- Toxic chemicals.

Total particulates were considered because even though the individual constituents may not be toxic, high air concentrations of particulates can interfere with breathing. Both liquid droplets and solid particles are considered particulates. Corrosives and irritants are chemicals that can cause damage to organs such as the eyes, skin or lungs, and usually exhibit a rapid effect. Toxic chemicals are chemicals that can affect other vital organs. The risk acceptance guidelines were based on emergency response planning guidelines (ERPG) using the techniques developed by the management and operating (M&O) committee (Craig 1993). Risk acceptance guidelines were developed for chemicals of interest where no ERPGs existed.

The ERPG limits are based on a 1-hour exposure. Accident scenarios may involve releases for longer periods of time, but the chemicals involved here are self alerting: that is, the maximum onsite and offsite individuals will be aware of the exposure because of unpleasant odors, irritation, or visible plumes. Doses from radiological releases are based on the assumption that the maximum onsite/offsite individual will remain at the plume centerline for up to 8 hours onsite and 24 hours offsite. Radiological releases may have no immediately detectable effects, but this is not true of toxic chemical releases from the tank farms. Because of the alerting nature of the tank farm chemicals, it is assumed that exposed individual will remove themselves from the plume or be evacuated within 1 hour.

Section 3.1 describes the generation of the chemical inventory and source terms. Section 3.2 gives the calculational methods used to determine the concentration the maximum onsite and offsite individual would be exposed to for a unit release. The toxicological risk acceptance guideline limits are

presented in Section 3.3 and Section 3.4 describes the comparison of calculated concentrations for unit releases to the risk acceptance criteria.

3.1 CHEMICAL INVENTORY AND SOURCE TERM DEVELOPMENT

The method of determining the composition of the liquids and solids is discussed in Section 3.1.1, and the method of determining the solid and liquid concentrations are given in 3.1.2. Both the gas composition and concentrations are discussed in Section 3.1.3.

3.1.1 Chemical Composition of Tank Waste

The toxic chemical concentrations for tank farm waste are determined based on an evaluation of the currently available data characterizing the tank waste. The data used include both sample data and values that were calculated from process flow sheets. Sources for sample data included the following:

- *Radionuclide and Chemical Inventories for the Double-Shell Tanks*, WHC-SD-WM-TI-543 (Van Vleet 1993a)
- *Radionuclide and Chemical Inventories for the Single-Shell Tanks*, WHC-SD-WM-TI-565 (Van Vleet 1993b)
- *High-Level Waste Tank Subcriticality Safety Assessment*, the tank sample analysis data base prepared by the WHC Risk Assessment Technology group (SARR-003 1994)
- Files of sample data collected by the Tank Characterization program
- Tank Characterization Reports
- The Tank Contents Data Base maintained by Pacific Northwest Laboratories for WHC
- The track radioactive components (TRAC) data base (*TRAC: A Preliminary Estimation of the Waste Inventories in Hanford Tanks through 1980* [Jungfleisch 1984] does not contain actual sample results but does give calculated concentrations of radionuclides derived from process flow sheets)
- *Estimated Chemical and Radiochemical Inventories Spreadsheet: NE Quadrant, A, AX, B, BX, BY, C Farms* (Agnew 1994a) and *Estimated Chemical and Radiochemical Inventories Spreadsheet: SW Quadrant, S, SX, U Farms* (Agnew 1994b) (These two documents do not contain actual sample results but give calculated concentrations of radionuclides and chemicals derived from process flow sheets and historical data on transfers in and out of the Hanford tanks).
- *Toxicological Evaluation of Analytes from Tank 241-C-103* (Mahlum 1994)

The term "analyte" is actually more accurate than "chemical" when referring to sample data because laboratory analyses of waste samples are typically designed to detect elements and ions, rather than full-molecule chemicals. The term "analyte" is used here when referring to sample data.

Much of the sample data is for ionic or elemental chemical forms, but hazards from chemical releases generally must be evaluated based on chemical compounds. Chemists familiar with tank waste and the processes from which the waste originated compiled a list of potential compounds formed by each analyte.

The tank waste is assumed to have a basic pH created by addition of sodium hydroxide. The validity of assuming that the tank waste is basic, has been confirmed by several chemists. Process technical manuals (e.g., GE 1944), as well as the *Final Environmental Impact Statement — Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes* (DOE-RL 1987), confirm this assumption also. The waste generated in the 1960s was neutralized to a pH of at least 8. Waste generated in the 1970s was neutralized to pH ranging from 8 to 10. Waste generated in the 1980s was neutralized to pH ranging from 12 to 14. Identification of chemical compounds was based on the assumption that the pH in the tanks is greater than 7.

Once the potential compounds had been identified, they were evaluated to determine which ones warranted release consequence evaluations. Each analyte detected in the tank was considered and compounds that were judged to exist in the tank with a pH in the basic range were listed. The compounds were evaluated to determine whether they could pose an exposure hazard as a toxin or as a corrosive or irritant. The compounds considered are summarized in Appendix A.1.

It is recognized, given the uncertainties of tank waste composition, and the complexities of tank waste chemistry, that selection of the chemicals for consideration is one of the major uncertainties in this process. Many different chemicals have been used in the different process that made up Hanford operation. Many of these chemicals have been placed in the tanks along with the radioactive waste. Additional compounds may have been produced due to interactions among chemicals, and the storage of up to 50 years in a radiation environment. The screening process has attempted to identify chemicals that are an acute exposure hazard. The list of over 150 chemicals shown in Appendix A.1 has been screened down for evaluation to approximately 70 chemicals associated with 24 analytes. If a particular analyte occurred in several toxic compounds, the limits for the analyte were based on the most restrictive compound. Analytes not associated with any hazardous compound were not evaluated further.

Examples with arsenic, silver, and calcium compounds illustrate the selection process. Arsenic and arsenic compounds $NaAsO_3$, Na_3AsO_4 and $NaAsO_2$ were identified as possible compounds in the tank waste. All these compounds were identified as toxic. The arsenic analyte was therefore selected as an analyte that required concentration information. For the silver analyte, the compounds Ag_2O and AgCl are expected to be found in the tank. It was concluded that these compounds were not an acute inhalation hazard. The silver analyte was therefore not selected for further evaluation. Calcium was identified as having compounds $CaCO_3$, $CaOH\text{-}SiO_2$-gels, and $Ca(OH)_2$. The

hydroxide was determined to be an inhalation hazard since it is a corrosive compound. The calcium analyte was selected for evaluation, and all the calcium was assumed to be $Ca(OH)_2$ even though some of the calcium would be present in noncorrosive Ca compounds. This evaluation process was repeated for the analytes listed in Appendix A.1.

Additional steps were taken to ensure that chemicals that could have a significant toxic effect were considered. A list was compiled from the available data bases of every chemical that had ever been detected in the Hanford waste tanks. This list is shown in Appendix A.2. Two senior chemists who are familiar with the chemistry, and the history of the waste tanks reviewed this list to determine whether additional chemicals should be added to the list of toxic chemicals. Their comments have been included in the final list in Appendix A.1. Two letters written documenting their conclusions are presented in Appendix A.3.

3.1.2 Liquids and Solids Chemical Concentration Determination

Sample data were evaluated separately as solids or liquids. Solids include data from waste samples labeled as solid, sludge, crust, saltcake, slurry/sludge, and solid/sludge. Liquids include data from waste samples labeled as liquid, supernate (or supernatant), drainable liquid, slurry, and convective layer liquids. The all-liquids composite was created by selecting the higher concentrations of the double-shell tank (DST) liquids and single-shell tank (SST) liquids for each analyte. The all-solids composite was created by selecting the higher concentration for each analyte of the DST solids and SST solids composites.

The composites were formed by taking the worst case concentrations for all the analytes in all the tanks in that composite grouping. Thus, the arsenic concentration used for the SSTs liquids is the largest valid arsenic concentration measured in all the SSTs liquid samples. The As concentration was taken from Tank C-110. The barium concentration was taken from tank BY-102. The concentration for other analytes was determined similarly. The composites are conservative in that they consist of the worst case concentration for each analyte in all the different tanks in the composite.

The composites selected for toxicological evaluation are different than the composites used for the radiological evaluation. For instance, the SST flammable gas watchlist tanks were broken off as separate composite for the radiological analysis while they are grouped with the other SST tanks for the chemical evaluations. The radiological accident evaluation for the SST required the more realistic consequence evaluations resulting from this finer subdivision. While this subdivision could have been made for the chemical evaluations also, the subdivision was not needed to demonstrate compliance with the risk guidelines. Since the use of a coarser division results in reduced manpower and costs, the coarser division was used for the toxicological analysis.

The inventory data for each tank include analyte concentrations for those analytes for which a laboratory analysis has been performed. By using the available data and selecting the highest analyte concentrations from the

different tanks to create a composite inventory, a sound basis exists for estimating conservative source terms for the toxicological alveolation of tank wastes.

The composite can be thought of as representing a single tank that contains the highest concentration for each analyte of concern found in the sample data. The following are the basic assumptions and bases for determining the concentrations in the tanks:

- The chemical concentrations are assumed to represent the entire volume of waste in the tank.

  Basis: Although actual concentrations will vary in different locations in the tank, the impact of these variations is reduced by using the highest concentrations found in that tank grouping.

- Tank liquids are assumed to have a density of 1.1 g/cm^3 (69 lb/ft^3) and tank solids are assumed to have a density of 1.6 g/cm^3 (100 lb/ft^3).

  Basis: (WHC 1995).

The process was similar to that used to determine the radionuclide inventories described in SARR-016. Scatter plots were developed for the 24 selected analytes. The concentrations were reviewed by a panel to determine which points should be used for calculating the toxicological release consequences. The review panel consisted of a chemist from the analytical laboratories, two experienced engineers from process chemistry, a representative from waste tank operations, an experienced engineer from Tank Waste Remediation System engineering, an engineer from ICF-Kaiser who provided data base support, and a safety analyst. The review panel used their cumulative knowledge of the Hanford chemical separations processes, references on the history of the Hanford tank farms, and files of laboratory sample reports to evaluate the sample points.

A validation document (WHC 1995) contains all of the scatter plots that were used to document the panel's rationale for rejecting or accepting sample points. The recommended maximum concentrations for each of the analytes was to used to compare against risk acceptance criteria as described in Section 3.5. An example of a scatter plot and a Concentration Data Evaluation form are given in Appendix A.4.

After the maximum sample analyte concentrations were established, a maximum sample concentration composite was created for eight tank groupings. For example, the maximum sample activity composite for DST liquids represents a single tank containing the highest concentration for each analyte found in the sample data for all DST liquids. This method of generating composites results in conservative hypothetical composites. Maximum sample composites were developed for the following eight liquid and solids tank groupings:

- SST liquids
- SST solids
- DST liquids

- DST solids
- DST flammable gas watch list liquids and solids
- All-solids
- All-liquids
- C-106 solids.

Analyte concentrations for each composite are shown in Table 3-1.

A calculation was also performed for a 50% NaOH solution because a credible accident scenario had been identified involving this solution at the 204 AR rail car facility. The NaOH was assumed to have a density of 1.5 g/cm^3 (94 lb/ft^3).

Data are given for both sodium and sodium hydroxide concentrations. The sodium concentration in this report was corrected so that the sodium is not counted twice. The sodium concentration was corrected by subtracting the sodium hydroxide concentration times the fraction of sodium in sodium hydroxide (23/40) from the measured sodium concentration. The total organic compounds (TOC) was similarly corrected by subtracting the oxalate concentration.

3.1.3 Tank Headspace Gas Inventory Evaluation

The tank headspaces contains gases that are released from the waste due to continuing chemical reactions within the waste. Accidents that result in venting of the headspace could release toxic gases. The gases used for evaluation in this report are intended to envelope the gases in all 177 waste tanks. An active program is being conducted to sample and analyze headspace gases. The gases selected will be based on the data available at present, and will be updated as more data becomes available.

Consultation with the experts conducting gas sampling indicated that the data at present indicates that Tank 241-C-103 contains the highest concentration of organic gases. A detailed evaluation of the headspace gases for tank 241-C-103 has been conducted based on their toxicity and concentration by the Tank Farm Toxicology Review Panel (Mahlum 1994). This reference (Mahlum 1994) is given in Appendix B.1. The Toxicology Review Panel selected twelve gases for further consideration based on the gas concentrations and relative toxicity. Theses gases are listed in Table 3-2 and are included in the toxicological evaluation in this SAR. Concentration data for these twelve gases were taken from Birn (Birn 1994), which is given in Appendix B.2.

Higher concentrations of ammonia and nitrous oxide have been detected in the head spaces in tanks other than C-103 (such as C-106). Even larger ammonia and nitrous oxide concentrations exist in slurries in tanks such as 241-SY-101, and a release to the headspace, such as occurs in a tank "burp," can result in extremely high concentrations. Calculations in Appendix J of SARR-65, which discusses flammable gas concentrations, indicate that the maximum headspace concentrations could be as large as 6.1% (61,000 ppm) for ammonia and 6.7% (67,000 ppm) for nitrous oxide. The limiting nitrogen and ammonia concentrations assumed in Appendix J of SARR-065 for the flammable gas

Table 3-1. Tank Waste Liquids and Solids Analyte Concentrations (Revised). (2 sheets)

Analyte	Composites concentrations (g/L)							
	SST solids	SST liquids	DST solids	DST liquids	DST flamm. gas watch list	All liquids	All solids	C-106 solids
Ammonia (NH3)	3.3 E-01	5.1 E-01	6.6 E+00	7.1 E+00	7.1 E+00	7.1 E+00	6.6 E+00	3.3 E-01
Antimony (Sb)	1.5 E+00	3.6 E-03	9.5 E-03	6.4 E-03	6.4 E-03	6.4 E-03	1.5 E+00	
Arsenic (As)	1.2 E+00	3.0 E-03	5.7 E+00	8.7 E-03	3.3 E+00	8.7 E-03	5.7 E+00	5.9 E-02
Barium (Ba)	4.0 E+01	5.3 E-02	5.9 E+00	3.3 E-02	5.9 E+00	5.3 E-02	4.0 E+01	7.8 E+00
Beryllium (Be)	2.6 E-02	3.0 E-04	1.4 E-01	3.8 E-03	1.4 E-01	3.8 E-03	1.4 E-01	2.6 E-02
Cadmium (Cd)	1.7 E+00	5.0 E-02	2.6 E+01	7.0 E-02	1.6 E-01	7.0 E-02	2.6 E+01	7.7 E-02
Calcium (Ca)	5.1 E+01	1.1 E+00	2.6 E+01	1.3 E+00	2.1 E+00	1.3 E+00	5.1 E+01	1.9 E+01
Cerium (Ce)	9.0 E-01	1.8 E+00	2.6 E+00	5.8 E-02	2.6 E+00	1.8 E+00	2.6 E+00	0.90 E-01
Chromium (Cr+3)	6.9 E+01		1.5 E+02		2.0 E+01		1.5 E+02	2.5 E+00
Cobalt (Co)	5.4 E-01	1.3 E-03	6.5 E-01	8.8 E-03	6.5 E-01	8.8 E-03	6.5 E-01	1.6 E-02
Cyanide (Cn)	2.8 E+00	5.3 E+00	4.7 E-01	9.1 E-02	4.7 E-01	5.3 E+00	2.8 E+00	9.6 E-02
Dysprosium (Dy)								
Lanthanum (La)	5.0 E+01	1.9 E-01	3.0 E+01	1.0 E+00	3.0 E+01	1.0 E+00	5.0 E+01	5.0 E+01
Mercury (Hg)	5.4 E+01	3.1 E-01	1.2 E-01	2.4 E-04	3.2 E-02	3.1 E-01	5.4 E+01	5.2 E-01
Neodymium (Nd)	2.3 E-01	1.4 E-01	7.0 E+00	5.6 E-03	7.0 E+00	1.4 E-01	7.0 E+00	2.3 E-01
Oxalate (C2O4)	2.8 E+02		2.8 E+02		1.2 E+02		2.8 E+02	2.8 E+02
Selenium (Se)	3.5 E+00	8.2 E-02	2.4 E-01	2.8 E-01	2.4 E-01	2.8 E-01	3.5 E+00	
Sodium Hydroxide (NaOH)	2.1 E+02	2.1 E+02	2.3 E+02	2.1 E+02	2.3 E+02	2.1 E+02	2.3 E+02	2.1 E+02

Table 3-1. Tank Waste Liquids and Solids Analyte Concentrations (Revised). (2 sheets)

Analyte	Composites concentrations (g/L)							
	SST solids	SST liquids	DST solids	DST liquids	DST flamm. gas watch list	All liquids	All solids	C-106 solids
Sodium (Na) - NaOH*	4.8 E+02	2.1 E+02	3.4 E+02	2.1 E+02	2.8 E+02	2.1 E+02	4.8 E+02	4.6 E+01
Tellurium (Te)	2.0 E-01	[a]	9.3 E-01	2.7 E-03	9.3 E-01	2.7 E-03	9.3 E-01	2.0 E-01
Thallium (Tl)	1.2 E+00	3.2 E-03	1.5 E+01	3.7 E-02	1.5 E+01	3.7 E-02	1.5 E+01	[a]
Total Organic Carbon (TOC)-Oxalate[b]	7.5 E+01	4.0 E+01	7.5 E+01	4.0 E+01	3.2 E+01	4.0 E+01	7.5 E+01	7.5 E+01
Uranium (U)	2.8 E+02	1.8 E+00	4.4 E+01	1.1 E+01	3.9 E-01	1.1 E+01	2.8 E+02	5.9 E-01
Vanadium (V)	3.3 E-02	4.1 E-03	4.1 E-02	2.1 E-03	4.1 E-02	4.1 E-03	4.1 E-02	1.9 E-02

[a]The best available data indicates there is not significant concentrations of this analytes in this composite.

[b]To avoid counting the same analyte twice, the oxalate concentration was subtracted from the TOC concentration and NaOH was subtracted from the Na concentration.

DST = Double-shell tank.

SST = Single-shell tank.

Table 3-2. Headspace Gas Composite Concentrations.

	Worst case composite[a]		Maximum steady state sample composite[b]	
Gas	Concentration (ppmv)	Concentration (mg/m^3)[c]	Concentration (ppmv)	Concentration (mg/m^3)*
Acetonitrile	13	21.8	13	21.8
Ammonia	61,300	40,000	2,000	1300
Benzene	0.4	1.3	0.4	1.3
1,3 Butadiene	0.1	0.19	0.1	0.19
Butanol	58	164	58	164
Dodecane	45	296	45	296
2-Hexanone	0.8	2.7	0.8	2.7
Methylene chloride	2	22	2	22
Nitrous oxide	67,000	110,000	1,400	2,340
Propanenitrile	5	11	5	11
Tributyl phosphate	1	12	1	12
Tridecane	50	390	50	390

[a]Based on worst case composites including slurry gas released.
[b]Based on worst case steady state samples, does not include slurry gas releases.
[c]The conversion from ppmv to mg/m^3 assumes a temperature of 38 °C (100 °F) and a pressure of 740 torr (0.1 MPA).

calculations are assumed for the toxicological evaluations. It is recognized that these concentrations are higher than steady state values by a significant factor (the highest steady state ammonia value measured in C-106 is about 1,000 ppm). This safety analysis is intended for use with a variety of accident scenarios, some of which could involve a slurry releases, so the limiting values for ammonia and nitrous oxide are therefore used. This composites is referred to a worst case composite.

The gas concentrations used in this report to compare against risk acceptance criteria were therefore based on the 241-C-103 for the organics with ammonia and nitrous oxide based on 241-SY-101 slurry releases. The concentration data for the chemicals of concern are shown in Table 3-2. A second gas composite was formed assuming the ammonia and nitrous oxide concentrations are based on maximum steady state sample data. This composite is referred to as the maximum sample data composite. The concentrations are the same for all gases except the ammonia and nitrous oxide. Headspace sample data for ammonia have indicated that most ammonia concentration values are less than 100 ppm, but 4 tanks exceed 500 ppm, with a peak of 1040 ppm. Most

nitrous oxide concentrations are also less than 100 ppm, but 7 tanks exceed 500 ppm with a peak of 701 ppm. Since the sampling program is still underway, larger concentrations may be found in other tanks. A concentration of 2,000 ppm for ammonia, and 1,400 ppm for nitrous oxide will be assumed for this composite. Concentrations for this composite are also shown in Table 3-2. It is important to recognize that this lower concentration composite can be used only when justified, e.g. for accident that are not associated with or could induce a release of slurry gases.

The program for sampling gases in tank headspace will not be completed until 1996. The data in Table 3-2 will need to be updated as more data become available. Gases which theoretically might exist in the tanks have not been included when the gas sampling has not detected the gas. Further study and sampling of headspace gases are still required to determine if additional gases need to be added to the list. Hydrogen cyanide (HCN) is an example. An active program was conducted to determine if HCN is present in the head space because ferrocyanide has been added to some of the tanks. An analytical evaluation concluded that HCN will not exist in a caustic environment (see Appendix A.1). A sampling program was conducted to locate HCN, and the gas was not found to be present. However, it must be noted that all tanks were not sampled, and while the tank contents are intended to be kept at a high pH to prevent corrosion, it is possible that some tanks, or regions of tanks, may have a lower pH. The ERPGs for HCN are about a factor of forty more restrictive than that of ammonia. Since large ammonia concentrations are assumed, the presences of small concentrations of HCN may not significantly affect the safety evaluations. It is, however, important to update the gas composition in the safety analysis as more information becomes available on gas sampling to determine the impact of revisions in gas species or gas concentrations.

Combustion product gases have not been included in this evaluation. Further evaluations may indicate the need for including the effects of these gases in accident scenarios involving fires.

It should be noted that accident scenarios involving releases of both solid or liquids, and gases need to consider the health effects of combined exposures.

3.2 DETERMINATION OF CONCENTRATIONS AT THE MAXIMUM ONSITE/OFFSITE INDIVIDUAL

Concentration for unit releases were determined using a plume dispersion model consistent with the NRC Reg guide 1.145 (NRC 1982). The meteorology used in the analysis is discussed in Section 3.2.1. The equation used to determine the concentrations at the onsite and offsite individuals are given in 3.2.2.

3.2.1 Meteorology and Atmospheric Dispersion Coefficients

The atmospheric dispersion coefficient (χ/Q') is the time-integrated normalized air concentration at the receptor. The coefficient represents the dilution of an airborne contaminant caused by atmospheric mixing and

turbulence and is the ratio of the average contaminant air concentration at the maximum onsite and offsite individual locations to the contaminant release rate at the release point. It is used to determine the consequences for the maximum onsite and offsite individuals based on the (1) source term, (2) atmospheric conditions, and (3) the distance to the maximum onsite/offsite individual.

The consequences for the maximum onsite individual are calculated at 100 m (0.06 mi) from the release point for ground level releases. The consequences to the maximum offsite individual are calculated based on the distance from the release point to the Site boundary.

The Site boundary χ/Q' values are based on the minimum distance from the nearest tank farm (or associated waste transfer lines) to the Hanford Site boundary to the nearest tank farm (Table 3-3). All χ/Q' values in this report are generated using the GXQ computer program, Version 3.1C (Hey 1993a, 1993b). The meteorological data used by GXQ are in the form of joint frequency tables. The joint frequency data are the most recent data available; they are nine-year averaged data (1983-1991) from the Hanford Site meteorology tower located in the 200 Area. All GXQ atmospheric dispersion coefficients are generated using the methods described in *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*, Regulatory Guide 1.145 (NRC 1982). The correction models available in GXQ (e.g., plume meander, plume rise, building wake, plume depletion) are not employed. This approach is conservative because all of these models reduce the airborne concentration at the maximum onsite and offsite individual locations.

The χ/Q' used in this analysis are the same as those used for the radiological release evaluations. The development of the χ/Q' is described in more detail in the radiological analysis topical (SARR-016).

The GXQ program has been verified and benchmarked against the GENII computer code (Napier et al. 1988). The program is also verified to produce χ/Q' values consistent with Regulatory Guide 1.145 methodology (NRC 1982). Tables 3-4 contains the χ/Q' values used to evaluate the maximum onsite and offsite individual toxicological consequences in this report. A description of each of the χ/Q' values is provided below.

Bounding χ/Q' values were generated consistent with the methods described in Regulatory Guide 1.145 (NRC 1982). Since atmospheric conditions fluctuate, a bounding atmospheric condition is determined to be that condition which causes a downwind concentration of airborne contaminants that is exceeded only a small fraction of time because of weather fluctuations. Regulatory Guide 1.145 defines this fraction of exceedance as 0.5% for each sector or 5% for the overall Hanford Site. The Hanford Site is broken up into 16 sectors, which represent 16 compass directions (i.e., S, SSW, SW, ..., ESE, SE, SSE). For each of the scenarios, χ/Q' values are generated for weather conditions that result in downwind concentrations exceeded only 0.5% of the time in the maximum sector or 5% of the time for the overall Site. These χ/Q' values are also referred to as 99.5% maximum sector and 95% overall Site χ/Q' values. The greater of these two values is called the bounding χ/Q' value and is used

Table 3-3. Site Boundary Distances for Tank Farms.*

Transport direction	Distance (m)
S	16,650
SSW	16,650
SW	13,875
WSW	11,100
W	11,100
WNW	11,100
NW	14,800
NNW	14,800
N	16,650
NNE	23,125
NE	19,425
ENE	15,725
E	15,725
ESE	21,275
SE	24,975
SSE	21,275

*Site boundary distances are the minimum distances from the nearest tank farm (or associated waste transfer lines) to the current Hanford Site boundary.

Table 3-4. Centerline Atmospheric Dispersion Coefficients for 200-Area Tank Farm Acute Release for Maximum Onsite and Maximum Offsite Individuals Located in Worst Sector.

Maximum individual	Bounding integrated χ/Q' (s/m^3)	Maximum puff χ/Q ($1/m^3$)
Onsite Sector and distance	3.44 E-02*	9.85 E-03 E 100 m
Offsite Sector and distance	1.88 E-05 W 11,100 m	4.45 E-08 E 15,725 m

*This value based on 95% overall Site in accordance with Regulatory Guide 1.145. See the radiological topical for further details (SARR-016).

to assess the dose consequences in the scenarios. These bounding χ/Q' values represent minimum dispersing conditions that result in maximum downwind concentrations (i.e., concentrations exceeded only a very small fraction of the time). These χ/Q' values will therefore, result in very conservative estimates of consequences. Table 3-4 contains bounding χ/Q' values for the maximum onsite and offsite individuals.

3.2.2 Determination of Concentrations at the Maximum Onsite/Offsite Individual

The major toxicological exposure pathways for tank farm accidents are inhalation of airborne particulates or gases. The term particulate is assumed to include both solid and liquids (droplets). Inhalation consequences depend on several variables:

- Chemical compounds and quantities released
- Resuspension rate or aerosolization to form respirable particles
- Dispersion of airborne particles or gases before they reach exposed individuals.

The calculation method is based on the use of ERPG limits as recommended by Craig (1993). The ERPG limits are based on a 1-hour exposure. It is assumed that individuals will not remain exposed to significant concentrations of these chemicals longer than 1-hour because the composites always include chemicals, such as sodium hydroxide, that are self-alerting because of their irritation, odor, and visible plumes. The calculation method is based on the assumption that the exposure is infrequent, and does not include such items as incremental cancer risk. Cancer risk data are largely based on prolonged exposure to chemicals and therefore are not applicable to a safety analysis which evaluates low frequency accidental exposures. The method is consistent with the state of the art for safety analyses of releases of chemical mixes.

For solids and liquids, concentrations at the maximum offsite and onsite individual were evaluated for unit releases and unit release rates. For gases and vapors, concentrations were evaluated for unit volume releases and unit volume release rates. Releases were evaluated under conditions of (1) ground level release, (2) 99.5% meteorology, and (3) steady-state and puff releases. Consequences are reported for a 100-m location, or maximum onsite individual, and the Hanford Site boundary, or maximum offsite individual. See Section 3.2.1 for a more complete explanation of the meteorology.

3.2.2.1 Peak Concentration Calculation Methods for Solid and Liquid Toxic Chemical Releases. The peak concentration is of concern for releases of chemicals. For a continuous release, the integrated χ/Q' is used. For instantaneous or short duration releases, the maximum puff χ/Q' should be used. There can be significant windward diffusion for release durations that have a plume travel time that is long in comparison to the release duration. Hence, the use of the integrated plume χ/Q' values for deriving peak air concentration for an instantaneous release is overly conservative. (A release is essentially instantaneous when its release duration is much less than the plume travel time to the maximum onsite/offsite individual). Maximum puff χ/Q

values should be used for the release durations shown in Table 3-5. The values in this table are derived by dividing the puff χ/Q into the continuous release χ/Q.' The results of the puff and continuous release models are equal at the times specified in Table 3-5. It is overly conservative to use the puff model for longer times or the continuous release model for shorter times.

Table 3-5. Release Durations for Which the Maximum Puff χ/Q Values Should be Used.

Release	Duration
Onsite receptor ground-level release	≤3.5s
Offsite receptor ground-level release	≤420s

The integrated plume χ/Q' values (without plume meander) are used for release durations longer than those shown in Table 3-5. For a continuous release of solid or liquid toxic materials, the peak concentration should be calculated using the following equation:

$$C\ (mg/m^3) = Q'\ (mg/s) \times \frac{\chi}{Q'}\ (s/m^3)$$

where

C = Peak concentration
Q' = Toxic material release rate
χ/Q' = Continuous release atmospheric dispersion coefficient.

The puff release χ/Q' should be used for an instantaneous release of solid or liquid toxic materials. The following equation is used to calculate the peak concentration for an instantaneous release of solid or liquid toxic material:

$$C\ (mg/m^3) = Q\ (mg) \times \frac{\chi}{Q}\ (1/m^3)$$

where

C = Peak concentration
Q = Toxic material released
χ/Q = Puff release atmospheric dispersion coefficient.

3.2.2.2 Peak Concentration Calculation Methods for Gaseous Toxic Chemical Releases. The equations provided below calculate the peak concentration from gaseous toxic material releases. The equations include corrections for the fact that the standard Gaussian equations assume a point release with zero source volume. The correction is necessary because the equations, which are

based on a point release, grossly overestimate peak concentrations as the volume released or the volumetric release rate becomes large or as the distance to the receptor becomes small. Because the source concentration is fixed, the peak concentration should approach the source concentration as the volume released or the volumetric release rate increases. The peak concentration should also approach the source concentration as the source to maximum onsite/offsite individual distance decreases. The equations given below provide the correct peak concentrations for both small and large gaseous toxic material releases. The GENII computer code uses this model to correct the χ/Q' for nonzero source volumes (Napier et al. 1988).

The peak concentration for gaseous releases of toxic materials at the receptor depends on the source concentration, the χ/Q' value, and the volume or volumetric flow rate of the release. For a continuous release of gaseous toxic materials, the peak concentration should be calculated using the following equation:

$$C\ (mg/m^3) = \left[\frac{\frac{\chi}{Q'}\left[\frac{s}{m^3}\right]}{\left[1 + V'\left[\frac{m^3}{s}\right] \times \frac{\chi}{Q'}\left[\frac{s}{m^3}\right]\right]}\right] \times S\left[\frac{mg}{m^3}\right] \times V'\left[\frac{m^3}{s}\right]$$

where

C = Peak concentration
S = Gaseous toxic material source concentration
χ/Q' = Continuous release atmospheric dispersion coefficient
V' = Volume release rate of gaseous source.

For an instantaneous release of gaseous toxic materials the puff release χ/Q should be used to calculate the peak concentration as shown in the following equation:

$$C\ (mg/m^3) = \left[\frac{\frac{\chi}{Q}\left[\frac{1}{m^3}\right]}{\left[1 + V\ (m^3) \times \frac{\chi}{Q}\left[\frac{1}{m^3}\right]\right]}\right] \times S\left[\frac{mg}{m^3}\right] \times V\ (m^3)$$

where

C = Peak concentration
S = Gaseous toxic material source concentration
χ/Q = Puff release atmospheric dispersion coefficient
V = Volume of gaseous source released.

3.2.2.3 Peak Concentration Methods for Total Particulates. For a puff release of tank material, the total particulate concentration at the maximum onsite/offsite individual is given by the following equation:

$$C = \rho \times 10^6 \times Q \times \chi/Q$$

where

- C = Concentration at the maximum onsite/offsite individual (mg/m^3)
- Q = Release amount (L)
- χ/Q = Puff atmospheric dispersion coefficient ($1/m^3$)
- ρ = Density of source material (g/cm^3).

The constant 10^6 is a unit conversion, and results from multiplying a factor of 1,000 to convert liters to cubic centimeters and by another factor of 1,000 to convert grams to milligrams. Densities of 1.6 g/cm^3 and 1.1 g/cm^3 (100 lb/ft^3 and 69 lb/ft^3) are assumed for the tank solids and liquids, respectively. This calculation is very conservative in that it assumes all material released is in the form of small particles that would be transported to the exposed individual. In practice, a significant fraction of the released material would be deposited near the release point.

The formula for the concentration from a continuous release of particulates is:

$$C = \rho \times 10^6 \times Q' \times \chi/Q'$$

where

- C = Concentration at the maximum onsite/offsite individual (mg/m^3)
- Q' = Release amount (L/s)
- χ/Q' = Continuous release atmospheric dispersion coefficient (s/m^3)
- ρ = Density of source material.

3.3 CHEMICAL RISK ACCEPTANCE GUIDELINES

Risk acceptance criteria used depend on the frequency of the event and the whether the maximum onsite or offsite individual is being evaluated. Events that may cause releases of toxic chemicals are categorized into four frequency categories. The categories are shown in Table 3-6. More restrictive chemical risk acceptance criteria are applied to the higher frequency events. The philosophy and application of limits are described in the WHC safety analysis manual WHC-CM-4-46.

Table 3-6. Hazard Frequency Definitions.

Frequency category	Category description	Frequency per year
Anticipated	An abnormal event that is expected to occur once or more during the lifetime of the facility (e.g., small radioactive materials spills, small fires).	10^{-2} to 1
Unlikely	Individually, the condition is not expected to occur during plant lifetime, but collectively, events in this category may occur several times.	10^{-4} to 10^{-2}
Extremely unlikely	Extremely low probability conditions that are not expected during the plant lifetime but that represent extreme or limiting cases of faults identified as possible. This category includes design basis accidents.	10^{-6} to 10^{-4}
Incredible	Accident for which no credible scenario can be identified.	$<10^{-6}$

A waiver to WHC-CM-4-46 allows use of the more technically justified toxicological risk guidelines in Craig (1993) rather than the risk guidelines originally given in WHC-CM-4-46. The waiver is shown in Appendix C. WHC-CM-4-46 was modified in March of 1995 to be consistent with this waiver. The Craig guidelines are based on permissible exposure limits - time weighted average (PEL-TWA) and ERPG values. Chemical-specific concentrations are determined for each of these values. For chemicals for which these values did not exist, conservative substitutes, referred to as "surrogates," or values derived by a Hanford Environmental Health Foundation (HEHF) toxicologist were used. The processes used to establish the limits are described in detail in Appendix D.

The M&O step criteria (Craig 1993) contain the chemical concentration guidelines used to evaluate the acceptability of the risk of the releases from a toxicological health effects point of view. The risk acceptance guidelines are given in terms of ERPG and PEL-TWA values for the maximum onsite and offsite individuals as a function of the accident frequency. The guidelines are given in Table 3-7.

Table 3-7. Risk Acceptance Guidelines for Toxicological Health Effects.

Event frequency	Onsite	Offsite
10^{-2} to 10^{0}	$\leq$ ERPG-1	$\leq$ PEL-TWA*
10^{-4} to 10^{-2}	$\leq$ ERPG-2	$\leq$ ERPG-1
10^{-6} to 10^{-4}	$\leq$ ERPG-3	$\leq$ ERPG-2

*The smaller of the ERPG-1 and the PEL-TWA value was used for the offsite limit.

The following are the definitions for ERPGs and PEL-TWA from Craig (1993).

- The ERPG-1 value is the maximum airborne concentration to which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.
- The ERPG-2 value is the maximum airborne concentration to which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.
- The ERPG-3 value is the maximum airborne concentration to which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.
- The PEL-TWA value is the employees' average airborne exposure in any 8-hour work shift of a 40-hour work week that shall not be exceeded.

The PEL-TWA use for emergency response is not strictly appropriate since the PEL-TWA is designed to control relatively long term worker exposure, rather than the short term exposure to the public that would be expected for accident response. The lower of the ERPG-1 and the PEL-TWA was used for the off-site exposure for high frequency events. Use of the limits that are at or below the ERPG-1 accident category provides an additional level of conservatism.

No published ERPG values existed for a number of chemicals found in the tanks. Therefore HEHF developed ERPGs for these chemicals using the methods and format of the American Industrial Hygiene Association (AIHA) (AIHA 1989), except that secondary references were used.

The following assumptions and methods were used in developing the ERPG values.

- All airborne particulates are considered to be inhalable.
- All inhaled particulates are considered to be retained.
- All inhaled particles are considered to be absorbed, thus contributing to the dose.
- All doses are calculated to occur over 1 hour. It is assumed that because the materials involved are irritating and easily detectable, exposure time will be limited.

- Because the evaluation is performed for an accident analysis, all doses are considered on a once-in-a-lifetime basis; effects that would occur only as a result of chronic exposure are not considered.

- Primary consideration is given to the most serious, or the most likely, effect on an acute basis (i.e., if a substance is toxic, but so irritating that a toxic dose is not likely to be inhaled, irritation is the primary effect).

- The categories of effects defined in the ERPG criteria are used.

- The hierarchy of data listed in the documents by the AIHA (AIHA 1989) and the National Research Council's Committee on Toxicology (NRCCOT) (NRCCOT 1986) is used.

- Extrapolation of data, from oral to inhalation and animal to human, is done according to approaches suggested by the NRCCOT (NRCCOT 1986).

Risk guidelines were developed for each compound that was determined to be a acute inhalation hazard. The selection of the risk guideline is explained in Appendix D.

3.4 COMPARISON TO RISK GUIDELINES

In developing the limits used to evaluate the consequences of accidental releases of solids and liquids from the tanks, the chemicals were separated into three categories:

- Total particulates
- Corrosives and irritants
- Toxic chemicals.

Total particulates are considered because, even though the individual constituents may not be toxic, high air concentrations of particulates of any chemical can interfere with breathing. Corrosives and irritants are chemicals that can cause damage to eyes, skin, or lungs, and that usually exhibit a rapid effect. Toxic chemicals are chemicals that can affect other vital organs.

The evaluation was conducted under the following assumptions.

- The particulate, corrosive, and toxic effects can be considered separately.

  Basis: Because the chemicals act independently and in different ways, the effects can be treated separately. This is consistent with American Conference of Governmental Industrial Hygienists (ACGIH) ACGIH (1992) and U.S. Environmental Protection Agency (EPA) (51 FR 34014) recommendations.

- Major effects of the chemical are caused by inhalation.

  Basis: Although skin and eyes can be effected by corrosives and irritants, limits are based on the most restrictive effect that results from inhalation.

- Particles reaching the maximum onsite/offsite individual are assumed to be respirable.

  Basis: The RF is dependent on the accident scenario. An RF is applied to the accident scenario if data are available; an RF of one is used if no data are available.

Each composite is evaluated for each of the three chemical categories. The most restrictive of the categories is used to evaluate the chemical consequences for the accident scenarios.

3.4.1 Total Particulates

The guidelines for particulates are from Dentler (1995):

- ERPG-3 = 500 mg/m^3
- ERPG-2 = 50 mg/m^3
- ERPG-1 = 30 mg/m^3
- PEL-TWA = 10 mg/m^3.

The bases for theses guidelines are described in Appendix D.

The guidelines to be used depend on the accident frequency class and whether the maximum onsite or offsite individual is being evaluated as shown in Table 3-7.

The equations in Section 3.3.2.3 can be used to determine the concentration for a 1 L/s (0.26 gal/s) continuous release or a 1-L (0.26 gal) puff release. The concentration is divided by the appropriate ERPG (depending on the location of the maximum onsite/offsite individual and the frequency class) to determine a constant that is multiplied by the release rate to determine the acceptability of a given scenario. A value less than or equal to one indicates the risk acceptance criteria have not been exceeded. The constants for particulates for each composite are given in Appendix E.

3.4.2 Corrosives and Irritants

Compounds that are corrosives or irritants are shown in Appendix D along with the PEL-TWA and ERPG limits. The derived and surrogate limits are discussed in detail in Appendix D. The items are listed in Appendix D by analyte, and each of the corrosives or irritants that was judged to be present in the tank waste is listed under the associated analyte. Where several compounds are possible, the limit for the most restrictive compound was chosen.

The comparisons to risk acceptance criteria for corrosive and irritating solids and liquids are made using the following steps.

1. For each of composites (DST liquids, DST solids, SST liquids, SST solids, all liquids, all solids, flammable gas watch list, C-106 solids, and NaOH), the chemical concentrations for each analyte, for both offsite and onsite maximum individuals, are calculated using the methods described in Section 3.3 for two types of unit releases (1 L/s for a continuous release, 1 L for a puff release).

2. For each calculation, the concentration of each analyte is divided by the appropriate risk guideline value (ERPGs or PEL-TWA) for each of three frequency classes (10^{-2} to 1, 10^{-4} to 10^{-2} and 10^{-6} to 10^{-4} per year).

3. The quotients are summed for all analytes for each maximum onsite/offsite individual, frequency class, composite, and release type. A value is computed for each of the composites two maximum individuals, two release types and three frequency classes. The sum can be calculated as follows:

$$S = \sum_{i=1}^{n} \frac{C_i}{G_i}$$

where

C_i = Concentration
G_i = Risk guideline.

This is referred to as the summing of fractions of health effects. The calculations are shown in detail for each composite in Appendix E.

The sum-of-fractions approach addresses situations in which mixtures of chemicals may include chemicals that have additive health effects. In the absence of information about which chemicals have additive effects, it was assumed that of the effects of chemicals in each health-effect type were additive. This approach is believed to be conservative because in general different chemicals will act on different organs. In many cases, the effects may be independent. It is true that in rare cases synergistic effects can make chemical combinations worse than the sum of the individual chemical effects, but the summing is judged to be conservative. Some chemicals also have antagonistic effects in which the sum can be less effective than the individual chemicals. The sum of fractions approach has been used in other applications. Examples of the sum of fractions approach are EPA (51 FR 34014) and (ACGIH 1994) guidelines.

3.4.3 Toxic Chemicals

Compounds that are considered toxic are shown in Appendix D along with the appropriate risk acceptance guidelines. The derived and surrogate limits are discussed in detail in Appendix D. Comparisons to risk acceptance

criteria for each compound of interest were made in a manner similar to that used for the corrosives and irritants. The results are shown in detail in Appendix E.

3.4.4 Gases

Comparisons to risk acceptance criteria for gases were made in a similar manner to that done for the liquids and solids except the gases were grouped according to three health effects categories:

1. Central nervous system depressants
2. Systemic poisons
3. Corrosives and irritants.

The risk guidelines are shown in Appendix D. The gas mixture was evaluated for each of the three health effects.

The following are additional assumptions in the analysis:

Asphyxiation was not considered because the chemicals involved are not chemical asphyxiant, and asphyxiation caused by oxygen displacement is not likely to be a problem at a distance of at least 100 m from the source.

Flammability limits were also not included, as this issue is addressed in detail in other reports for the tank farms.

3.4.5 Integration of Limits

Three sets of limits have been established for each solid and liquid composite: (1) particulate, (2) corrosive and irritating, and (3) toxic chemical as discussed in Sections 3.4.1, 3.4.2 and 3.4.3. Three sum-of-fractions limits are calculated for each composite each receptor, and each frequency class. The calculations are shown in Appendix E. The largest sum of fractions for each calculation is the most limiting, and is used for accident scenario evaluations. The largest sum of fractions results are shown in Table 3-8 for a 1 L/s (0.26 gal/s) continuous release and a 1-L (0.26 gal) puff release for each composite and both maximum onsite and offsite individuals.

Similarly, sum of fractions for the gases have been calculated for central nervous system depressants, systemic poisons, and corrosives and irritants as described in Section 3.4.4. The most restrictive sum of fractions for gases is shown in Table 3-8 for a 1-m^3 (35 ft^3) puff release and a 1 m^3/s (35 ft^3/s) continuous release for both maximum onsite and offsite individuals.

Table 3-8. Sum-of-Fraction of Risk Guidelines for a Unit Release of Chemicals and Gases. (3 sheets)

*The sum of fractions are multiplied by the release rate for continuous release and release amount for a puff releases. Release rates for continuous releases are in units of liters per second for liquids and solids, and m^3/s for gases. Puff release quantities are in units of liters for solids and liquids and m^3 for gases.

Tank waste type (Units of sum of fractions follow tank waste type)	Maximum individual	Accident frequency, 1/yr		
		$1 - 10^{-2}$	$10^{-2} - 10^{-4}$	$10^{-4} - 10^{-6}$
DST or SST solid or liquid continuous release				
Single-shell liquids(s/L)	Onsite	9.6 E+03	7.5 E+02	2.0 E+02
Single-shell liquids(s/L)	Offsite	5.4 E+00	5.4 E+00	4.2 E-01
Single-shell solids(s/L)	Onsite	3.9 E+04	2.0 E+03	9.8 E+02
Single-shell solids(s/L)	Offsite	6.3 E+01	2.2 E+01	1.1 E+01
Double-shell liquids(s/L)	Onsite	1.0 E+04	7.5 E+02	2.1 E+02
Double-shell liquids(s/L)	Offsite	5.6 E+00	5.6 E+00	4.2 E-01
Double-shell solids (s/L)	Onsite	1.7 E+04	2.4 E+03	5.6 E+02
Double-shell solids(s/L)	Offsite	1.3 E+02	9.5 E+00	1.4 E+00
DST or SST liquid or solid puff release				
Single-shell liquids (L^{-1})	Onsite	2.8 E+03	2.2 E+02	5.7 E+01
Single-shell liquids (L^{-1})	Offsite	1.3 E-02	1.3 E-02	9.9 E-04
Single-shell solids (L^{-1})	Onsite	1.1 E+04	6.0 E+03	2.9 E+02
Single-shell solids (L^{-1})	Offsite	1.5 E-01	5.2 E-02	2.7 E-02
Double-shell liquids (L^{-1})	Onsite	2.9 E+03	2.2 E+02	6.0 E+01
Double-shell liquids (L^{-1})	Offsite	1.3 E-02	1.3 E-02	9.9 E-04
Double-shell solids (L^{-1})	Onsite	5.0 E+03	7.1 E+02	1.6 E+02
Double-shell solids (L^{-1})	Onsite	3.0 E-01	2.3 E-02	3.2 E-03
Flammable gas watch list composite				
Continuous Release (s/L)	Onsite	1.3 E+04	1.1 E+03	2.6 E+02
Continuous Release (s/L)	Offsite	1.4 E+01	7.2 E+00	6.1 E-01
Puff Release (L^{-1})	Onsite	3.7 E+03	3.2 E+02	7.7 E+01
Puff Release (L^{-1})	Offsite	3.4 E-02	1.7 E-02	1.4 E-03

Table 3-8. Sum-of-Fraction of Risk Guidelines for a Unit Release of Chemicals and Gases. (3 sheets)

*The sum of fractions are multiplied by the release rate for continuous release and release amount for a puff releases. Release rates for continuous releases are in units of liters per second for liquids and solids, and m^3/s for gases. Puff release quantities are in units of liters for solids and liquids and m^3 for gases.

Tank waste type (Units of sum of fractions follow tank waste type)	Maximum individual	Accident frequency, 1/yr		
		$1 - 10^{-2}$	$10^{-2} - 10^{-4}$	$10^{-4} - 10^{-6}$
Gas Release - Worst Case Composite				
Continuous (s/m^3)	Onsite	7.7 E+01	9.4 E+00	1.9 E+00
Continuous (s/m^3)	Offsite	4.5 E-02	4.5 E-02	5.4 E-03
Puff (m^{-3})	Onsite	2.3 E+01	2.8 E+00	5.8 E-01
Puff (m^{-3})	Offsite	1.1 E-04	1.1 E-04	1.3 E-05
Gas Release - Maximum Sample Composite Note this data should be used only when the accident scenario does not involve a slurry gas release. Otherwise use the above sum of fractions.				
Continuous (s/m^3)	Onsite	2.6 E+00	3.3 E-01	7.1 E-02
Continuous (s/m^3)	Offsite	1.5 E-03	1.5 E-03	1.9 E-04
Puff (m^{-3})	Onsite	7.9 E-01	9.9 E-02	2.1 E-02
Puff (m^{-3})	Offsite	3.7 E-06	3.6 E-06	4.5 E-07
50% NaOH releases				
Continuous (s/L)	Onsite	1.3 E+04	1.0 E+03	2.6 E+02
Continuous (s/L)	Offsite	7.2 E+00	7.2 E+00	5.8 E-01
Puff (L^{-1})	Onsite	3.8 E+03	3.0 E+02	7.5 E+01
Puff (L^{-1})	Offsite	1.7 E-02	1.7 E-02	1.4 E-03
All liquids and all solids continuous release				
All liquids (s/L)	Onsite	1.0 E+04	7.5 E+02	2.1 E+02
All Liquids (s/L)	Offsite	5.6 E+00	5.6 E+00	4.2 E-01
All solids (s/L)	Onsite	4.8 E+04	2.2 E+04	1.2 E+03
All solids (s/L)	Offsite	1.7 E+02	2.7 E+01	1.2 E+01

Table 3-8. Sum-of-Fraction of Risk Guidelines for a Unit Release of Chemicals and Gases. (3 sheets)

*The sum of fractions are multiplied by the release rate for continuous release and release amount for a puff releases. Release rates for continuous releases are in units of liters per second for liquids and solids, and m^3/s for gases. Puff release quantities are in units of liters for solids and liquids and m^3 for gases.

Tank waste type (Units of sum of fractions follow tank waste type)	Maximum individual	Accident frequency, 1/yr		
		$1 - 10^{-2}$	$10^{-2} - 10^{-4}$	$10^{-4} - 10^{-6}$
All liquids or solids puff release				
All liquids (L^{-1})	Onsite	2.9 E+03	2.2 E+02	6.0 E+01
All liquids (L^{-1})	Offsite	1.3 E-02	1.3 E-02	9.9 E-04
All solids (L^{-1})	Onsite	1.4 E+04	6.4 E+03	3.4 E+02
All solids (L^{-1})	Offsite	4.0 E-01	6.3 E-02	2.9 E-02
C-106 solids				
Continuous (s/L)	Onsite	5.9 E+03	1.1 E+03	3.0 E+02
Continuous (s/L)	Offsite	6.8 E+00	3.3 E+00	6.1 E-01
Puff (L^{-1})	Onsite	1.7 E+03	3.2 E+02	8.8 E+01
Puff (L^{-1})	Offsite	1.6 E-02	7.7 E-03	1.4 E-03

The comparison to risk guidelines for chemical release consequences for a given accident scenario is determined using the following steps:

1. Determine the accident frequency range for the event.

2. Determine the type of material being released (i.e., SST solids or liquids, DST solids or liquids, flammable gas watch list composite, headspace gases, 50% NaOH, all solids, all liquids, or the C-106 composite).

3. Determine whether the release is a puff release or a continuous release. A release with a duration of less than 3.5 seconds can be treated as a puff release for maximum onsite individual evaluations. A release with a duration of less than 420 seconds can be treated as a puff release for maximum offsite individual evaluations.

4. Determine the release quantity or release rate. For puff releases of solids or liquids, the number of liters released is required; for continuous releases of solids or liquids, the release rate is required. For puff releases of gases, the number of cubic meters released is required; for continuous releases of gases, the release rate is required.

5. Multiply the release quantity or release rate determined in step 4 by the appropriate value from Table 3-8. The product is the sum of the concentrations divided by ERPG values. Values less than one indicate that the risk acceptance guidelines are met.

   NOTE: The concentration of gases at the receptor is not linear with release rate or release amount. Determining acceptability by multiplying the values in Table 3-8 by the release rate or amount results in an approximation. The approximation is conservative because using the linear relationship over-predicts concentrations for releases larger than 1 L (0.26 gal) or 1 L/s (0.26 gal/s). The difference between linear scaling and the more exact method is negligible below release rates of about 5 m^3/s (180 ft^3/s) or release amounts of 5 m^3 (180 ft^3). Because the nonlinear term in the gas equation is $1/(1 + V' \times \chi/Q')$, this effect is only significant for the maximum onsite individual. For the maximum offsite individual, $V' \times \chi/Q'$ will be much smaller than one for any credible release from the tanks. The largest offsite χ/Q' is 1.88×10^{-5} s/m^3 and all credible releases are much smaller than 10^5 m^3/s.

Step 5 can also be written as the following formulae:

- Liquid or solid continuous release:

  Sum-of-fractions of acceptance limits = [release rate] x [Table 3-8 continuous release value]

- Liquid or solid puff release:

  Sum-of-fractions of acceptance limits = [release quantity x [Table 3-8 puff value]

Accident scenarios involving a release of both gases and solid or liquids should be treated by adding the sum of fractions for the gases and liquids or solids together. That is, the quantity of gas released should be multiplied by the sum of fraction and the product determined. The quantity of liquid or solid should multiplied by the appropriate sum of fraction. To meet risk acceptance criteria, the sum of these two products must be less than or equal to one.

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APPENDIX A

SUPPORTING DATA FOR LIQUIDS AND SOLIDS CHEMICAL SELECTIONS

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APPENDIX A.1

WORKING TABLE USED TO DETERMINE

A: POTENTIAL COMPOUNDS IN THE TANK SOLIDS AND LIQUIDS

B: COMPOUNDS THAT ARE ACUTE INHALATION HAZARDS AND ARE INCLUDED IN THE RELEASES ASSESSMENTS

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Philosophy behind the table:

1. List all the elements, anions, cations, and compounds mentioned in:
   - WASTREN Single-Shell Tank Inventory document (acronym = SST)
   - WASTREN Double-Shell Tank Inventory document (acronym = DST)
   - Tank Farm Health & Safety Plan (acronym = HASP)
   - Plans for Tank Farm Historical Characterization Report (acronym = HCR)

2. Determine what compounds would be formed assuming an alkaline medium created by addition of NaOH.

3. Determine form and relative toxicity of compounds, and from that, determine if consequence assessment is necessary (or alternatively, if the "threshold quantity" approach or back-calculate-problem-quantity approach should be applied).

4. For chemicals worthy of consequence considerations, inventories from WASTREN inventory documents will be used to determine unit release consequences.

ACRONYMS:

TMB	Input provided by Todd Brown
DKO	Input provided by Dave Oestreich
DLH	Input provided by Dan Herting
DMS	Input provided by Denis Strachan
DST	Double-Shell Tank inventory document (estimate)
EDTA	Ethylenediaminetetraacetic acid
HASP	Tank Farm Health & Safety Plan
HB	Input provided by Harry Babad
HCN	Hydrogen cyanide
HCR	Historical Characterization Report plan
HEDTA	N-(2-Hydroxyethyl)ethylenediaminetriacetic acid
NPH	Normal paraffin hydrocarbon
PNOC	"Particulate not otherwise classified"
SST	Single-Shell Tank inventory document (estimate)
TBP	Tributyl phosphate
TOC	Total organic carbon
WIW	Input provided by Bill Winters

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
H_2O	HCR	NA	Liquid	No - not toxic
NO_3^{-1}	HCR, HASP, DST, SST	NaNO3 (sodium nitrate)	Liquid (in solution) Solid (crystallized salts)	Yes - Eye and mucous membrane irritant and toxic MLD Routinely encountered in consumer products, including food. All toxicity data derived from ingestion studies. Not listed in ACGIH or NIOSH.
NO_2^{-1}	HCR, HASP, DST, SST	NaNO2 (sodium nitrite)	Liquid (in solution) Solid (crystallized salts)	Yes - Eye and mucous membrane irritant and toxic MLD Routinely encountered in consumer products, including food. All toxicity data derived from ingestion studies. Not listed in ACGIH or NIOSH.
PO_4^{-3}	HCR, DST, SST	Possibly Na3PO4 [Sodium phosphate (tribasic) = Na3PO4*12HOH] GLB: Possibly Na2HPO4	Liquid (in solution) Solid (crystallized salts)	Yes - Severe eye and respiratory irritant MLD Not listed in ACGIH or NIOSH. Hawley's: "Toxic by ingestion, irritant to tissue... Used in water softeners, detergent, dietary supplements, food additives."
		BiPO4 [WIW: is insoluble phosphate]	Solid	No - Not an acute inhalation hazard MLD Not listed in ACGIH or NIOSH. Bi used in cosmetics and medicines. DKO: there are not many toxic inorganic phosphates.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		WIW: AlPO4 (insoluble phosphate) [See Al+3]	Solid	No - Not an acute inhalation hazard; solutions are corrosive due to acid solvent MLD Hawley's: Solutions corrosive to tissue, (insoluble in water & alcohol, slightly soluble in HCl and nitric acid); used in dental cements, cosmetics, & pharmaceuticals. Not listed in ACGIH or NIOSH.
		WIW: Polyphosphates (e.g., P2O7) may be possible DKO: Inorganic polyphosphates	Solid	No - Low toxicity, reversible eye/respiratory irritation MLD Not listed in ACGIH or NIOSH. (Except for the organophosphate esters, phosphates are generally not toxic.)
		DLH: Na7F(PO4)2 (sodium fluoride diphosphate)	Solid	No - [See sodium aluminum fluoride under F(-1)] MLD
		DLH: Organophosphate esters [See TBP]	Liquid	Yes - [See TBP, DBP, and MBP] MLD
CO_3^{-2}	HCR, DST, SST	WIW: Na2CO3 (primary) [See Na2CO3]	Solid and in solution	Yes - Corrosive, severe eye hazard MLD Is soda ash; not listed in ACGIH or NIOSH. Used in soaps & detergents.
		DKO: NaHCO3 (sodium bicarbonate)	Solid and in solution	No - Not an acute inhalation hazard MLD Used as oral antacid. Not listed in ACGIH or NIOSH.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		WIW: Insoluble CaCO3 possible if large amounts of Ca present (not frequent)	Solid	No - Not an acute inhalation hazard MLD Is dietary Ca supplement and "limestone". Hawley's: "nuisance particulate dust." WASTREN: Considered by ACGIH to be PNOC[1], which is related to generic safety issues and not toxicity.
F(-1)	HCR, DST, SST	NaF (sodium fluoride) DMS: Can become HF if pH drops below about 4. [See HF]	Liquid (in solution) Solid (crystallized salts)	Yes - Toxic and corrosive MLD NaF is highly toxic via ingestion and is used as rat poison. TLV-C of 2.6 mg/m3 and TLV-TWA of 2.5 mg/m3 as F address chronic inhalation exposure concerns.
		WIW: F^{-1} - BiPO4 process generated LaF3. [See La]	Solid	Yes - Toxic and corrosive MLD DKO: Metal complexes with F are sufficiently stable to prevent hydrolysis of F-1 to HF.
		WIW: Also, F^{-1} forms strong metal complexes with Fe, Al (e.g., Na3AlF6)	Liquid Solid	No - Not an acute inhalation hazard MLD DKO: Metal complexes with F are sufficiently stable to prevent hydrolysis of F-1 to HF.
		Na7F(PO4)2 (sodium fluoride diphosphate)[1]	Solid	No - Not an acute inhalation hazard MLD DKO: Metal complexes with F are sufficiently stable to prevent hydrolysis of F-1 to HF.
Cl^{-1}	HCR, DST, SST	NaCl (sodium chloride) - solution & crystallized salts	Liquid (in solution) Solid (crystallized salts)	No - Not an acute inhalation hazard MLD Is table salt. No hazard listed in Hawley's. Not listed in ACGIH or NIOSH.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
OH^{-1}	HCR, DST, SST	Free OH- ion	Liquid	Yes - MLD Covered by NaOH for SSTs, use OH- as indicator for NaOH in DSTs.
		See "hydroxided" cations and metals	NA	NA
Na DLH: Na+1; definitely no Na metal in the tanks[2]	HCR, DST, SST	NaOH (sodium hydroxide)	Liquid (in solution) Solid (crystallized salts)	Yes - Corrosive MLD Caustic and corrosive - hard on tissue. ACGIH TLV-C = 2 mg/m3. [Covered by NaOH]
		WIW: Also possible mineralization (possibly NaAlSiO2) DKO:Possibly ...SiO4, which is a silicate	Solid	No - Not an acute inhalation hazard MLD Insoluble and aren't very toxic.
		DMS: $Na_2S_2O_3$ (sodium thiosulfate)[3] DLH: Does not exist anymore because it is too reactive	NA because not present	Not an acute inhalation hazard MLD
		NaNO3 [See NO3] NaNO2 [See NO2] Na2SO4 [See SO2, SO3, SO4, and NaSO4] Na3PO4 [See PO4] DMS: NaAlO2 [See Al(+3)]	NA	[See specific compound entries]

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
Al (+3)	HCR, DST, SST	Al(OH)3 at pH < 13 DLH: "Gibbsite" is crystalline form DMS: "Hydroargelite" is gelatinous form [See Al(OH)4(-1)]	Solid at pH ≤ 9.5) Liquid (in solution) at pH > 10.5 DLH: [becomes NaAl(OH)4; listed separately]	No - Not an acute inhalation hazard MLD Hawley's: Used in cosmetics. Not listed in ACGIH or NIOSH.
		WIW: Al(PO4) [See PO4(-3)]	Solid	No - Not an acute inhalation hazard MLD
		WIW: NaAl(OH)4 (sodium aluminate) [also written as NaAlO2] at pH > 13. DKO: Considered by most to be a base, but considered by some to be a salt. Hawley's says sodium aluminate is NaAlO2 (which is a salt) [See Al(OH)4(-1)]	Liquid DLH: or solid salt	Yes - Liquid is corrosive MLD
		DLH: Al2(CO3)3 precipitate if lots of carbonate present [WIW questions this] [DLH has never encountered this in actual waste] [DMS: Unlikely to be present]	Solid	No - Not an acute inhalation hazard MLD Hawley's: aluminum carbonate insoluble in water, soluble in HCl or H2SO4. No hazard listed. Not listed in ACGIH or NIOSH.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		Also found as mineral form - cancrinite, zeolite, and sodium aluminosilicate are possibilities. DLH says we don't know, though we do know mineral forms of Al certainly exist in the tanks.	Solid	No - Not an acute inhalation hazard MLD Are insoluble and aren't very toxic.
		DMS: May be found in clay form (e.g., bentonite)	Solid	No - Not an acute inhalation hazard MLD
		AlOOH (boehmite) TMB: Crystals seen with X-ray diffraction in U-110.	Solid	No - Not an acute inhalation hazard MLD Not listed in ACGIH or NIOSH.
Fe (+2or3)	HCR, DST, SST	Fe(OH)3 (ferric hydroxide)	Solid	No - Not an acute inhalation hazard MLD No hazard listed in Hawley's. Not listed in ACGIH or NIOSH.
		Fe2(CO3)3 (ferric carbonate)	Solid	No - Not an acute inhalation hazard MLD Used as trace mineral added to animal feeds. No hazard listed in Hawley's. Not listed in ACGIH or NIOSH.
		Fe may also mineralize	Solid	No - Not an acute inhalation hazard MLD
Ca (+2)	HCR, DST, SST	CaCO3 (calcium carbonate) [See CO3]	Solid	No - Not an acute inhalation hazard MLD Is dietary Ca supplement and "limestone". Hawley's: "nuisance particulate dust." WASTREN: Considered by ACGIH to be PNOC[1], which is related to generic safety issues and not toxicity.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		DMS: Also present as CaOH-SiO2-H2O gels and compounds in cement/concrete	Gel, solid	Yes - Produces irritation similar to CaOH MLD
		DLH: Ca(OH)2 (calcium hydroxide)	Solid	Yes - Corrosive MLD Has TLV-TWA of 5 mg/m3 and Hawley's lists it as a skin irritant. Is a fairly common chemical - used in mortar, plasters, cements, depilatories (hair removal), soil conditioner, disinfectant, water softening, and food additives as buffer and neutralizing agent.
Bi (+3)[4]	HCR, DST, SST	BiPO4 (Bi phosphate) WIW: Good possibility since it was used in process. DLH: All of Bi in tanks is probably present as this. TMB: Saw crystals with X-ray diffraction of B-110 sample	Solid	No - Not an acute inhalation hazard MLD Bi compounds used extensively in cosmetics (e.g., lipstick), also in medicines. Not listed in ACGIH or NIOSH.
		Bi(OH)3	Solid	No - Not an acute inhalation hazard MLD Bi compounds used extensively in cosmetics (e.g., lipstick), also in medicines. Not listed in ACGIH or NIOSH.
		Bi2(CO3)3 DMS: Unlikely to be present	Solid	No - Not an acute inhalation hazard MLD No - Bi compounds used extensively in cosmetics (e.g., lipstick), also in medicines. Not listed in ACGIH or NIOSH.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
Cr (+3 or +6; both possible based on SST analyses)[5]	HCR, DST, SST	Cr+6 and Cr+3 are the toxic concerns	Liquid (+6)[6] Solid (+3)[5]	Yes -Water-soluble hexavalent chromium compounds are acute inhalation hazards; TLV based on preventing respiratory irritation MLD No - Insoluble hexavalent and tri- and di-valent compounds are chronic inhalation hazards only MLD
		Cr(NO3)3 (Cr as Cr+3) - WIW: only if pH is relatively low (<7), which is not the case in the tanks DLH: Does not exist at all	Solid (possibly a gel)	Yes - Irritant MLD Actually NA because not present at high pHs. [Covered by Cr+3]
		Cr(OH)3 if Cr is +3 and pH is high	Solid	Yes - Irritant MLD [Covered by Cr+3]
		WIW: Na2CrO4 (sodium chromate)	Liquid	Yes - Irritant MLD [Covered by Cr+6]
Zr (+4)	HCR, DST, SST	Zr(OH)4	Solid	No - Not an acute inhalation hazard MLD There is a TLV-TWA for Zr compounds (5 mg/m3 as Zr). NIOSH Publication No. 81-123 states "Zr compounds are of generally low toxicity... There are no well-documented cases of toxic effects from industrial exposure."
		ZrO2*nH2O DMS: This is the most likely Zr(+4) form	Solid	No - Not an acute inhalation hazard MLD See entry for Zr(OH)4.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		WIW: Zr forms complex salts. May form zirconyl compounds - $ZrO(NO_3)_2$ DLH: Zirconyl compounds probably do not exist in tanks	Solid	No - Not an acute inhalation hazard MLD See entry for $Zr(OH)_4$.
		WIW: $ZrF_6(-2)$ or $ZrOF_2$ [Zr cladding was dissolved in NH_4F] DLH: $ZrF_6(-2)$ exists only in acid and neutral solutions - not in waste tanks. $ZrOF_2$ probably does not exist in tanks. DMS: Solutions were made alkaline before sending to the tanks.	Solid	No - Not an acute inhalation hazard MLD See entry for $Zr(OH)_4$.
Si WIH: +4	HCR, DST	SiO_2 (silica, quartz, minerals) DMS: Minerals - see compounds with Na, Al, and Ca	Solid	No - Not an acute inhalation hazard MLD Si was added to the tanks in the form of waterglass and diatomaceous earth.
		HB: Diatomaceous earth	Solie	No - Not an acute inhalation hazard MLD
		WIW: Na_4SiO_4 ("waterglass," sodium silicate)	Liquid	Yes - Corrosive as a liquid MLD Used to coat eggs to keep them fresh. Waterglass is an amorphous form of silica, as opposed to a crystalline form of silica.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
TOC	HCR, DST, SST	Many organic chemicals HB: A wide variety of complexant fragments, mostly sodium salts	Gases, liquids, and solids[8]	Yes - Irritant and toxic MLD [See TBP, DBP, and MBP]
FeCN[9] [$Fe(CN)_6(-4)$]	HCR SST	NA [WIW: Na2NiFe(CN)6, Na2Fe(CN)6] DKO: These not likely because Fe3(+2)[Fe(CN)6(-3)]2 (ferrous ferricyanide) and Fe4(+3)[Fe(CN)6(-4)]3 (ferric ferrocyanide) will form[10] WIW: DKO's suggestion not clear. Na2NiFe(CN)6 is insoluble (solid). Na2Fe(CN)6 and Na3Fe(CN)6 are soluble	Probably solid	<u>Ferric and ferrocyanides [Na2NiFe(CN)6]:</u> No - Not an acute inhalation hazard; ferric and ferrocyanides do not release CN when metabolized MLD <u>Soluble ferricyanides [Na2Fe(CN)6]:</u> Yes - soluble ferricyanides metabolize to CN in vivo MLD (per Dave Bechtold) Looked at for energetics only, and is common chemical (is the blue in blueprints). Hawley's: used in printing inks, cosmetics, fertilizer; no hazard listed. Latimer: "ferrous and ferric ions form complex ions [that] are so stable that their solutions show virtually none of the properties of the iron or cyanide ions." The TLV for CN does not apply to complex ions like ferrocyanides. Also, per Joe Meacham, if a free cyanide intermediate is formed in tank solutions, it is quickly destroyed by hydrolysis. (Harry Babad and others agree.)
		WIW: NaCN DLH: Not present because cyanide would have hydrolyzed long ago (DMS and WIW disagree[11])	?	Yes - Extremely toxic; CN released <u>in vivo</u> MLD

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
U WIW: UO2+2	HCR, DST, SST	DKO: Insoluble U compounds	Solid	Yes - Toxic MLD Listed in ACGIH and NIOSH for toxicological reasons.
NPH[12]	HASP	DKO: Remains as NPH (a kerosene-type compound, dodecane and tridecane forms of NPH) WIW: 1. C10 - C15 aliphatic. 2. Hydrolysis, radiolysis and nitration will degrade NPH with time.[13]	Liquid	Yes - Liquid aerosol extremely irritating to lungs and toxic; vapor much less irritating, but central nervous system toxicity is roughly the same MLD Not listed in ACGIH or NIOSH.
Ammonia (NH_3)[14]	HASP, DST, SST	NH3 (alkaline drives NH3 off into headspace) DMS: Gas solubilities could be about 0.6% NH_3 in these solutions. If pressure is relieved, the gas will come out of solution.	Primarily gas	Yes - Strong irritant and toxic MLD
		WIW: NH4NO3 (ammonium nitrate) possible if pH < 11 (much < 11 per DKO)	Liquid	Yes - Severe irritant MLD Used by public routinely as fertilizer. Hawley's: "strong oxidizing agent." Not listed in ACGIH or NIOSH.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
Acetone	HASP	Acetone	Liquid	Yes - Irritant and toxic MLD Used by public routinely as nail polish remover. Very high TLV-TWA of 1780 mg/m3. High volatility reduces ability to be transported downwind (evaporates and diffuses by itself) Generally considered as one of the least toxic solvents. A relatively high vapor pressure suggests that it will preferentially evaporate from solution and should not be present in many (if any) tanks except transitorily. Very large doses via immersion or ingestion are needed [to produce health effects from] acute exposures. Lower doses are required to produce toxic effects by inhalation.
Butanol (Butyl alcohol)	HASP	Butanol (Butyl alcohol) (1-butanol or n-butyl alcohol)	Liquid and vapors	Yes - Irritant and toxic MLD Hawley's: "Toxic on prolonged inhalation, irritant to eyes, absorbed by skin". High "limits": TLV-C = 152 mg/m3, IDLH = 8000 ppm. High volatility reduces ability to be transported downwind (evaporates and diffuses by itself).
TBP	HASP	Tributylphosphate (TBP)	Liquid and vapor	Yes - Irritant and toxic MLD TLV-TWA value provided by ACGIH.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		DLH: Dibutyl phosphate (DBP) is a TBP degradation product, but is probably too reactive (hydrolyzable) to be around still. (DMS disagrees[15])	Liquid and vapor	Yes - Irritant and toxic MLD Not listed in ACGIH or NIOSH. Not identified as a vapor of concern by the Toxicology Review Panel. Since no data is available specifically for DBP concentration, evaluations of DBP releases cannot be made. However, the consequences should be bounded by the TBP evaluations because all of the total organic carbon (TOC) is assumed to be TBP, which is conservative because TBP is heavier and more toxic than DBP.
		DLH: Monobutyl phosphate (MBP) is a TBP degradation product, but is probably too reactive (hydrolyzable) to be around still. (DMS disagrees[15])	Liquid and vapor	Yes - Irritant and toxic MLD Not listed in ACGIH or NIOSH. Not identified as a vapor of concern by the Toxicology Review Panel. Since no data is available specifically for MBP concentration, evaluations of MBP releases cannot be made. However, the consequences should be bounded by the TBP evaluations because all of the total organic carbon (TOC) is assumed to be TBP, which is conservative because TBP is heavier and more toxic than MBP.
		HB: Sodium salt of TBP (stable)	Solid	Yes - Toxic and irritant MLD
		HB: Sodium phosphate (from unstable sodium salt) [See PO_4^{-3}]	NA	See sodium phosphate under PO_4^{-3}
		HB: Butanol (from unstable sodium salt) [See Butanol]	NA	See Butanol

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		Possibly other TBP degradation products	Liquid and vapor	Since no speciation is available for other TBP degradation products, further evaluations of liquid releases cannot be made. However, the consequences should be bounded by the TBP evaluations because all of the total organic carbon (TOC) is assumed to be TBP, which is conservative because TBP is heavier and more toxic than its degradation products.
Formic acid[6] DLH: (cannot exist in tanks)	HASP	HCOONa (sodium formate) DKO: salt of formic acid, deliquescent (becomes liquid by absorbing moisture from air) DMS: Has been identified in Tank 241-SY-101 waste	Solid and Liquid	Yes - Corrosive and toxic; forms formic acid on contact with moist membranes MLD Not listed in ACGIH or NIOSH.
		DMS: Na-oxalate	Mostly solid	Yes - Corrosive and toxic; forms oxalic acid MLD
Hydrogen	HASP	H2	Gas	No - Unless concentration high enough to displace air in breathing zone MLD Evaluated for energetics (not toxicity)

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
H_2S[17]	HASP	Metal sulfides [WIW: FeS, Fe2S3 oxidizes to sulfates] DKO: Any sulfide ion in solution would be precipitated. Most heavy metal sulfides (e.g., iron, nickel) are insoluble WIW: Free sulfide ions or H2S are rapidly oxidized if not complexed with metals. DMS: H_2S is unlikely unless pH drops below about 7 or 8. There must also be low O_2 partial pressure.	Solid	No - Some are toxic (iron, cobalt, and nickel sulfides) but very high concentrations are required by inhalation; total particulate limits prevent toxicity due to release of H2S in stomach MLD [Covered by S] Note: H2S is volatile and very toxic, but can't exist at hi pH.
		DMS: CoS (formed during ferrocyanide campaigns)	Solid	Yes - Toxic and corrosive MLD

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
HCN[18]	HASP	WIW, DKO: FeCN DMS: FeCN does not exist in tanks HB: No HCN detected in vapor analysis of alkaline Hanford tanks [See FeCN]	Solid	No - Not an acute inhalation hazard (is not metabolized to CN) MLD Looked at for energetics only, and is common chemical (is the blue in blueprints). Hawley's: used in printing inks, cosmetics, fertilizer; no hazard listed. Latimer ref: "ferrous and ferric ions form complex ions [that] are so stable that their solutions show virtually none of the properties of the iron or cyanide ions." The TLV for CN does not apply to complex ions like ferrocyanides. Also, per Joe Meacham, if a free cyanide intermediate is formed in tank solutions, it is quickly destroyed by hydrolysis. (Harry Babad and others agree.) HB: Reference available from Dan Reynolds. Note: Although HCN is very volatile & toxic, it is an acid gas and can't exist at hi pHs.
SO_2[19]	HASP	Na2SO3 (sodium sulfite) [WIW: probably not stable in waste - will oxidize to Na2SO4]	Solid	No - Not an acute inhalation hazard MLD Not listed in ACGIH or NIOSH. Note: SO2 does not exist in the tanks.
SO_3[20]	HASP	Na2SO4 (sulfate) [See Na, SO2, SO4, NaSO4]	Solid	No - Not an acute inhalation hazard MLD Hawley's: Used as filler in detergents, pharmaceuticals, food additive. Not listed in ACGIH or NIOSH.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
HF^{21}	HASP	NaF (fluoride) [See F-1]	Solid	Yes - Highly toxic by inhalation MLD [NaF is highly toxic via ingestion and is used as rat poison. TLV-C of 2.6 mg/m3 and TLV-TWA of 2.5 mg/m3 as F address chronic inhalation exposure concerns.]
		WIW: Metal fluorides [See F-1]	Solid	No - Not an acute inhalation hazard, except for LaF_3 and other alkali metal fluorides MLD
Ag^{22}	DST, SST	Ag2O	Solid	No - Not an acute inhalation hazard MLD The TLV-TWA for soluble compounds (0.01 mg/m3, as Ag) is based on chronic dust hazards. It is not an acute inhalation hazard.
		WIW: AgCl - not much chloride	Solid	No - Not an acute inhalation hazard MLD Hawley's: no health hazard listed. Insoluble silver compounds not listed in ACGIH or NIOSH.
$Al(OH)_4^{-1}$	DST, SST	WIW: NaAlO2 [sodium aluminate; also written as NaAl(OH)4] [See Al+3]	Liquid or solid	Yes - Corrosive MLD Hawley's: strong irritant to tissue. Not listed in ACGIH or NIOSH.
As	DST, SST	As is the toxic concern	Solid	Yes - Toxic MLD Soluble As compounds are toxic. TLV-TWA = 0.2 mg/m3 as As, based on chronic exposure hazards.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		NaAsO3 (metaarsenate) or Na3AsO4 (orthoarsenate) [DLH: ArsenITES, like NaAsO2, are very easily oxidized and probably don't exist in the waste]	Solid	Yes - Toxic MLD Hawley's: toxic by ingestion & inhalation, soluble in water, slightly soluble in alcohol. [Covered by As]
B	DST, SST	Na3BO3 or Na2B4O7 (sodium borate)	Solid (from common ion effect)	<u>Na3BO3:</u> No - Not an acute inhalation hazard MLD <u>Na2B4O7:</u> Yes - Corrosive MLD Same as "Boraxo," which is a common household chemical. Hawley's: used in detergents, herbicides, fertilizers, pharmaceuticals, bleaches.
Ba	DST, SST	Ba is the toxic concern	Solid and possibly liquid	Yes - Soluble barium compounds are both irritant and toxic MLD Bronchial irritation has been reported from the inhalation of Ba carbonate dust. Ba hydroxide and Ba oxide are strongly alkaline in aqueous solution, causing severe burns of the eye and irritation of the skin.
		WIW: Ba(OH)2	Solid	Yes - Strong irritant MLD [Covered by Ba]
		WIW: BaCO3	Solid DLH: very insoluble	Yes - Strong irritant MLD [Covered by Ba]

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		WIW: $Ba(NO_3)_2$ DLH: will not exist under basic conditions because $Ba(OH)_2$ will predominate	Liquid	Yes - Strong irritant MLD [Covered by Ba]
Be	DST, SST	Be is the toxic concern	Liquid	Yes - Toxic and irritant MLD
		WIW: $Be(OH)_2$	DKO: Solid at pH 5-8 DKO: Liquid at pH >8 because forms complex ions [e.g., $Be(OH)_4^{(-2)}$]	Yes - Toxic and irritant MLD [Covered by Be]
		WIW: Na_2BeO_2 DLH: Same as $Na_2Be(OH)_4^{(-2)}$	Liquid	Yes - Toxic and irritant MLD [Covered by Be]
CN^{-1}	DST, SST	NaCN [WIW: See FeCN; CN^{-1} forms complexes with many metals] [See TOC]	Liquid (in solution as Na^+ and CN^- ions)	Yes - Extremely toxic MLD Per Joe Meacham, if a free cyanide intermediate is formed in tank solutions, it is quickly destroyed by hydrolysis. (Harry Babad and others agree.)
Cd	DST, SST	$Cd(OH)_2$ MLD: Cd comes from dissolution of fuel rods DKO: Cd was neutron poison	Solid	Yes - Toxic and irritant MLD DKO: For Cd dust exposure, 9 mg/m3 breathed for 5 hr was fatal; as element: is volatile at high temperature

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
Ce	DST, SST	Ce(OH)3 (cerous hydroxide)	Solid (gel)	Yes - Toxic MLD Not listed in ACGIH or NIOSH.
Co[23]	DST, SST	Co is toxic concern	Solid	Yes - Irritant and toxic MLD
		Co(OH)2 (cobaltic hydroxide)	Solid	Yes - Irritant and toxic MLD Compound not listed in ACGIH or NIOSH, although there is a TLV-TWA of 0.05 mg/m3 for Co as Co metal dust and fume. [Covered by Co]
		Co2O3*H2O (same as cobaltic hydroxide per Hawley's)	Solid	Yes - Irritant and toxic MLD Compound not listed in ACGIH or NIOSH, although there is a TLV-TWA of 0.05 mg/m3 of Co as Co metal dust and fume. [Covered by Co]
CrO_4 DLH: CrO4(-2)	DST	Na2CrO4 (sodium chromate) [See Cr]	Liquid	Yes - Corrosive MLD [Covered by Cr]
Cu	DST, SST	Cu(OH)2	Solid	No - Very high concentrations would be required for a one-hour exposure in order to produce the symptoms of metal fume fever; total particulate limits prevent such concentrations of copper MLD

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
Dy	DST, SST	WIW: Dy(OH)3 [Dy is in tanks because it is a fission product, although a VERY LOW yield fission product]	Solid	Yes - Strong irritant MLD DyOH much weaker than NaOH so toxicity much worse for NaOH. Dy, a rare earth, is not particularly hazardous; not listed in ACGIH or NIOSH.
EDTA	DST, SST	Na4*EDTA	Liquid	No - Not an acute inhalation hazard; may be protective against metal absorption MLD
HEDTA	DST, SST	Na3*HEDTA	Liquid	No - Not an acute inhalation hazard; may be protective against metal absorption MLD
Hg^{24}	DST, SST	Hg is the toxic concern	Solid or liquid	Yes - Toxic MLD
		WIW: Hg(OH)2	Solid	Yes - Toxic MLD [Covered by Hg]
		WIW: Hg metal DKO: will probably exist as solid salt	Solid	Yes - Toxic MLD [Covered by Hg]
		WIW: HgOH	Solid	Yes - Toxic MLD [Covered by Hg]
K	DST, SST	WIW: KNO3	Liquid	No - Not an acute inhalation hazard MLD Hawley's: used in matches, fertilizer, curing foods; not listed in ACGIH or NIOSH.
La	DST, SST	La(OH)3	Solid	Yes - Corrosive and toxic MLD Not listed in ACGIH or NIOSH.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		[La fluoride per WIW & DKO because of process used] WIW: LaF3 [See F(-1)]	Solid	Yes - Corrosive and toxic MLD DKO: Metal complexes with F are sufficiently stable to prevent hydrolysis of F-1 to HF.
		WIW: Insoluble phosphates, including LaPO4	Solid	Yes - LaPO4 Corrosive (because releases phosphoric acid in vivo) and toxic MLD Not listed in ACGIH or NIOSH.
Li	DST, SST	WIW: LiNO3	Liquid	Yes - Strong irritant MLD Not listed in ACGIH or NIOSH
Mg	DST, SST	Mg(OH)2	Liquid or solid	No - Not an acute inhalation hazard MLD Is "milk of magnesia" (an orally administered antacid). Also used in dentifrices, and for food drying and color retention. Not listed in ACGIH or NIOSH.
		MgCO3	Liquid Solid	No - Not an acute inhalation hazard MLD Used in dentifrices, cosmetics, antacid, foods (as drying, color retention, and anticaking agents). Not listed in ACGIH or NIOSH.
Mn	DST, SST	MnO2	Solid	No - Not an acute inhalation hazard MLD WASTREN: Although the TLV-TWA for Mn compounds is 5 mg/m3 as Mn, there are no reports of acute toxicity
Mo	DST, SST	Mo is the toxic concern	Solid	No - Not an acute inhalation hazard MLD

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		WIW: $Mo_2O_3 * H_2O$ (a molybdate) DKO: is a good oxidizer and probably won't stick around. Would become a lower oxidation state compound	Solid	No - Not an acute inhalation hazard MLD [Covered by Mo]
		WIW: Na_2MoO_4 (another molybdate) DKO: Also a good oxidizer	Solid	No - Not an acute inhalation hazard MLD [Covered by Mo]
Nd	DST, SST	$Nd(OH)_3$	Solid	Yes - Toxic MLD Not listed in ACGIH or NIOSH.
		WIW: NdF_3	Solid	Yes - Toxic and irritant MLD Neodymium compounds not listed in ACGIH or NIOSH.
Ni^{25}	DST, SST	Ni is the toxic concern	Solid or liquid	No - Not an acute inhalation hazard MLD
		WIW: $Ni(OH)_2$ (nickelous hydroxide)	Solid	No - Not an acute inhalation hazard MLD
		DKO: More likely $Ni(OH)_3$ (higher oxidation state) (nickelic hydroxide)	Solid	No - Not an acute inhalation hazard MLD
		DLH: $[Ni(OH)_4]^{-2}$	Liquid	No - Not an acute inhalation hazard MLD

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
Np	DST	WIW: NpO2OH	Solid	No - No data on chemical toxicity concentrations, possibly because first acute toxic effects are from radiation; limit by radiological concerns. MLD Not listed in ACGIH or NIOSH.
P	DST, SST	WIW: phosphates	Solid	NA - see specific phosphate compounds
Pb[26]	DST, SST	WIW: Pb(OH)2	Solid	No - Not an acute inhalation hazard; inorganic Pb does not exhibit acute exposure health effects MLD
Pd (Fission product)	DST, SST	WIW: Possibly Pd(OH)2 DKO: More likely Pd(OH)4 (higher oxidation state)	Solid	No - Not an acute inhalation hazard MLD No Pd compounds are listed in ACGIH or NIOSH.
		WIW: Also some complex nitrosyl compounds DKO: Not much NO around to form nitrosyls DLH: Don't know that they exist in the waste	Liquid soluble complexes	No - Not an acute inhalation hazard MLD No Pd compounds are listed in ACGIH or NIOSH.
Pu	DST, SST	DKO: Pu hydroxide	Solid	No - Although chemically toxic, first acute toxic effects are thought to be from radiation; not enough data on which to base chemical toxicity exposure guidelines; limit by radiological concerns MLD

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		Pu(+4)F4 DLH: Not in the tanks because all converts to hydroxide	Solid	No - Although chemically toxic, first acute toxic effects are thought to be from radiation; not enough data on which to base chemical toxicity exposure guidelines; limit by radiological concerns MLD DKO: Metal complexes with F are sufficiently stable to prevent hydrolysis of F-1 to HF.
Re	DST, SST	WIW: Possibly NaReO4 (rhenates) [surprised that Re is present] DKO: shouldn't be there - is not a fission product. HB: Re may not be present	DLH: Either liquid (as Na+ and ReO4- ions), or solid (ReO2) if behaves like permangenate (MnO4-) and is reduced in basic solution	No - Not an acute inhalation hazard MLD No Re compounds listed in ACGIH or NIOSH.
Rh (Fission product)	DST, SST	Rh is the toxic concern	Solid	No - Not an acute inhalation hazard MLD
		Rh2O3	Solid	No - Not an acute inhalation hazard MLD
		WIW: Nitrosyl compounds - see 1970 document by Vince Panesko ~~DKO: Only trace quantities in parallel universes~~	Unknown	No - Not an acute inhalation hazard MLD
Ru	DST, SST	DKO: Ru2O3	Solid	No - Not an acute inhalation hazard; ruthenium is limited by radiation guidelines MLD Not listed in ACGIH or NIOSH.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		DKO: RuO_4 (volatile tetraoxide) Hawley's: sublimes at room temp	Probably gas	Yes - Although solid and liquid forms are not an acute inhalation hazard, vapor forms are highly injurious to the eyes and mucous membranes (corrosive and toxic). Ruthenium is limited by radiation guidelines MLD Not listed in ACGIH or NIOSH.
		WIW: Na_2RuO_4 (sodium ruthenates have complex chemistry)	Liquid	No - Not an acute inhalation hazard; ruthenium is limited by radiation guidelines MLD Not listed in ACGIH or NIOSH.
SO_4^{-2}	DST, SST	Na_2SO_4 (sodium sulfate) [See Na, SO2, SO3 and $NaSO_4$]	Liquid	No - Not an acute inhalation hazard MLD Used as food additive and in detergents. Not listed in ACGIH or NIOSH.
		IIB: $BaSO_4$	Solid	No - Not an acute inhalation hazard; poorly absorbed MLD
		IIB: $CaSO_4$	Solid	No - Not an acute inhalation hazard MLD
		IIB: $SrSO_4$ [See Sr]	[See Sr]	[See Sr]
Sb	DST, SST	Sb is the toxic concern	Liquid or solid	Yes - Toxic and irritant MLD
		DLH: Possibly $NaSb(OH)_4$ (sodium antimonate)	Liquid (as Na^+ and $Sb(OH)_4^-$ ions)	Yes - Toxic and irritant MLD [Covered by Sb]
		DLH: Possibly Sb_2O_5 (antimony pentoxide, antimonic anhydride, antimonic acid, stibic anhydride)	Solid	Yes - Toxic and irritant MLD [Covered by Sb]

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
Se	DST, SST	Se is the toxic concern	Probably liquid	Yes - Toxic MLD
		Na_2SeO_4 (sodium selenate) DLH: Possibly Na_2SeO_3 (sodium selenite)	Liquid	Yes - Toxic MLD [Covered by Se]
		WIW: SeO_2 (complex chemistry) DKO: Won't have this because can't exist in alkaline pH	Unknown	Yes - Toxic MLD [Covered by Se]
Sn	DST, SST	Sn is the toxic concern	Solid or liquid	No - Not an acute inhalation hazard MLD
		$Sn(OH)_2$ (tin hydroxide)	Solid	No - Not an acute inhalation hazard MLD
		SnO_2*H_2O (tin oxide)	Solid	No - Not an acute inhalation hazard MLD
		Na_2SnO_3 (sodium stannate) DLH: Same as $Na_2Sn(OH)_6$ (differing only by 3 water molecules). Both are the hydroxide complex ions discussed in the note above (see Ni) DKO: $Na_2Sn(OH)_6$ is NaOH + stannic hydroxide	Liquid	No - Not an acute inhalation hazard MLD
Sr	DST, SST	WIW: Sr sulfates	Solid	No - Not an acute chemical inhalation hazard MLD
		DKO: Sr carbonates	Solid	No - Not an acute chemical inhalation hazard MLD

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		DKO: Sr oxalates	Solid	Yes - Oxalates are chemically toxic MLD Not listed in ACGIH or NIOSH.
Ta	DST, SST	WIW: Possibly Na3TaO4 (sodium tantalate)	Liquid	No - Not an acute inhalation hazard MLD Patty's: "Tantalum and its compounds are nontoxic by all routes and exposure levels experienced under normal industrial operating conditions as would be expected from its complete inertness toward body tissues and fluids."
		WIW: Possibly Ta2O5*H2O (tantalum oxide) DKO: Ta is not there	Liquid	No - Not an acute inhalation hazard MLD Patty's: "Tantalum and its compounds are nontoxic by all routes and exposure levels experienced under normal industrial operating conditions as would be expected from its complete inertness toward body tissues and fluids."
Te	DST, SST	Te is the toxic concern DMS & HB: Probably not present or only as fission product	Solid or liquid	Yes - Toxic MLD
		WIW: Na2TeO3 (sodium tellurite) DKO: Na2TeO4 (sodium tellurate)	Liquid	Yes - Toxic MLD [Covered by Te]
		WIW: Possibly TeO2*H2O (tellurium dioxide) DKO: Not there (Te is sulfur-like)	Solid or liquid	Yes - Toxic MLD [Covered by Te]

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
Th	DST, SST	WIW: Possibly ThO2*H2O (thorium oxide) DMS (HB): Probably not present or only as fission product	Solid	No - Not an acute chemical inhalation hazard MLD Not listed in ACGIH or NIOSH.
		Th(OH)4 (thorium hydroxide)	Solid	No - Not an acute inhalation hazard MLD Not listed in ACGIH or NIOSH.
Ti	DST, SST	TiO2 (titanium dioxide) or Ti(O2)*H2O	Solid	No - Not an acute inhalation hazard MLD WASTREN: Titanium and its oxide (TiO2) are inert in physiological tissues.
		WIW: Ti(OH)4 (titanium hydroxide)	Solid	No - Not an acute inhalation hazard MLD Not listed in ACGIH or NIOSH.
		WIW: Na2TiO3 (sodium titanate or titanile)	Solid	No - Not an acute inhalation hazard MLD Not listed in ACGIH or NIOSH.
Tl	DST, SST	Tl is the toxic concern DLH: Has never heard of Tl being in the waste DMS: Not present except as possible fission product	Solid or liquid	Yes - Toxic MLD Hawley's: Tl forms toxic compounds on contact with moisture.
		WIW, DLH: Tl(OH)3 (thallium hydroxide) DLH: Possibly TlOH if is in +1 ion state	Solid at pH 8-12, liquid at pH >12 Solid	Yes - Toxic MLD Hawley's: Tl forms toxic compounds on contact with moisture. [Covered by Tl]

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
		WIW: $NaTlO_2$ (sodium thallate) DLH: Possibly $NaTl(OH)_4$	Solid or liquid	Yes - Toxic MLD Hawley's: Tl forms toxic compounds on contact with moisture. [Covered by Tl]
V DMS: V unlikely	DST, SST	WIW: $Na_2[VO_3(OH)]$ (sodium vanadate)	Probably liquid	Yes - Strong respiratory irritant MLD
		WIW: Na_4VO_4 (probably "sodium vanadite")	Probably liquid	Yes - Strong respiratory irritant MLD
		WIW: $NaVO_3$ (probably "sodium vanadate")	Probably liquid	Yes - Strong respiratory irritant MLD
W	DST	Na_2WO_4 (sodium tungstate) DMS: W not likely [See WO4]	Liquid	No - Not an acute inhalation hazard MLD Patty's: all the human toxicity information on W is chronic in nature
Zn	DST, SST	WIW: $Zn(OH)_2$ (zinc hydroxide)	Solid	No - Not an acute inhalation hazard MLD Not listed in ACGIH or NIOSH.
Am	SST	WIW: $Am(OH)_3$ (americium hydroxide)	Solid	No - No data on chemical toxicity concentrations, possibly because first acute toxic effects are from radiation; limit by radiological concerns. MLD Not listed in ACGIH or NIOSH.
$C_2H_3O_3$ (glycolate ion)[27]	SST	WIW: Possibly sodium glycolate	Liquid	No - Not an acute inhalation hazard MLD Hawley's: used in soaps, pharmaceuticals, meat preservations, food additives. Not listed in ACGIH or NIOSH.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
$C_6H_5O_7^{-3}$ (citrate ion)	SST	Na3C6H5O7 (sodium citrate)	Liquid	Yes - Irritant MLD Hawley's: strong irritant to skin & tissue, decomposes when exposed to CO2 in air. Food additive. Not listed in ACGIH or NIOSH.
$C_2O_4^{-2}$ WIW & DLH: (-2)	SST	Na2C2O4 (sodium oxalate) DKO: Probably not there because heavy metals precipitate oxalates before sodium does	Solid	Yes - Corrosive and toxic - forms oxalic acid when metabolized MLD Not listed in ACGIH or NIOSH.
		WIW: CaC2O4 (calcium oxalate)	Solid	Yes - Corrosive and toxic - forms oxalic acid when metabolized MLD Not listed in ACGIH or NIOSH.
		WIW: SrC2O4 (strontium oxalate)	Solid	Yes - Corrosive and toxic - forms oxalic acid when metabolized MLD
$NaAlO_2$	SST	NaAlO2 (sodium aluminate) [See Al(OH)4(-1)]	Liquid	Yes - Corrosive MLD Not listed in ACGIH or NIOSH.
Na_2CO_3	SST	Na2CO3 [See CO3-2]	Liquid	Yes - Corrosive MLD Hawley's: soda ash, used in soaps & detergents, Not listed in ACGIH or NIOSH.
$NaNO_2$	SST	NaNO2 (sodium nitrite) [See NO2(-1)]	Liquid (in solution) Solid (crystallized salts)	Yes - Irritant and toxic MLD Routinely encountered in consumer products, including food. All toxicity data derived from ingestion studies. Not listed in ACGIH or NIOSH.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
$NaNO_3$	SST	NaNO3 (sodium nitrate) [See NO3(-1)	Liquid (in solution) Solid (crystallized salts)	Yes - Irritant and toxic MLD Routinely encountered in consumer products, including food. All toxicity data derived from ingestion studies. Not listed in ACGIH or NIOSH.
NaOH	SST	NaOH (sodium hydroxide) [See OH-1, Na]	Liquid (in solution) Solid (crystallized salts)	Yes - Corrosive MLD
Na_3PO_4	SST	Na3PO4 (sodium phosphate) WIW: Possibly polyphosphates Sodium phosphate tribasic addressed in PO4(-3) [See PO4(-3)]	Liquid (in solution) Solid (crystallized salts)	Yes - Strong irritant MLD
$NaSO_4$ ion	SST	Na2SO4 [See Na, SO2, SO3, SO4]	Solid	No - Not an acute inhalation hazard MLD Hawley's: used as filler in detergents, pharmaceuticals, food additives, no hazard listed. Not listed in ACGIH or NIOSH.
S^{-2}	SST	Na2S (sodium sulfide)	Solid	Yes - Corrosive MLD Not listed in ACGIH or NIOSH.
		WIW: metal sulfides [See H2S - WIW: FeS, Fe2S3 oxidizes to sulfates]	Solid	No - Not an acute inhalation hazard; although toxic when swallowed due to release of H_2S, amount necessary to produce end effect is too great to inhale on acute basis. MLD

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant to Tox. Analysis? Why or Why Not?
SeO_4^{-2}	SST	Na2SeO4 DMS: SeO_4^{-2} not likely. [See Se]	Liquid	Yes - Toxic MLD [Covered by Se]
SiO_2	SST	SiO2 (silica, quartz) [See Si]	Solid	No - Not an acute inhalation hazard MLD Si was added to the tanks in the form of waterglass and diatomaceous earth.
		WIW: Na4SiO4 [See Si]	Liquid	Yes - Corrosive (because in liquid form) MLD Used to coat eggs to keep them fresh. Si was added to the tanks in the form of waterglass and diatomaceous earth.
		WIW: minerals [See Si]	Solid	No - Not an acute inhalation hazard MLD Si was added to the tanks in the form of waterglass and diatomaceous earth.
SiO_3 ion	SST	Na2SiO3 or 4 (sodium silicate)	Solid	Yes - Corrosive MLD Si was added to the tanks in the form of waterglass and diatomaceous earth.
WO_4 ion	SST	Na2WO4 (sodium tungstate) DMS: W not likely [See W]	Liquid	No - Not an acute inhalation hazard MLD Patty's: all the human toxicity information on W is chronic in nature.

Analyte	Where Mentioned	Potential Compounds in Basic pH Formed by Addition of NaOH	Form	Relevant Lo Tox. Analysis? Why or Why Not?
ZrO	SST	NaZrO (sodium zirconate) DMS: May also be in the form of Na_2ZrO_3	Solid	No - Not an acute inhalation hazard MLD NIOSH Publication No. 81-123 states "Zr compounds are of generally low toxicity... There are no well-documented cases of toxic effects from industrial exposure."

GENERAL NOTES FROM BILL WINTERS:

a. "Chemistry of +4 to +6 metals in basic solution is complex. Normally form hydroxides or hydrous oxides or for some metals they may form sodium salts such as aluminates."

b. "The amount of OH- used has varied with the history of Hanford. Early SSTs may have less OH- (lower pH) than later SSTs and DSTs. Most DSTs have relatively high (> pH 12) OH- concentrations. Early SSTs may have pHs between 8 and 10. Depending on when the waste was generated and the type of waste. Some types of early SST wastes (cladding waste) may have higher (> 12) pHs. All have been neutralized so that no acid species are expected."

ENDNOTES

1. Dan Herting:
   "Another apparently common (but little known) form of fluoride in the waste tanks is Na7F(PO4)2, sodium fluoride diphosphate - not sodium fluorophosphate as often mis-named. This salt has been identified as a major component in tank 110-U, and is presumably present in many other similar tanks... Exists as solid, certainly. In solution, probably exists as discrete fluoride and phosphate ions."

2. Dan Herting:
   "At least 70% of all Na+ in tank farms is associated with NO3- as NaNO3. NaNO2, Na2CO3, Na2SO4, Na3PO4, and NaAl(OH)4 make up another 29% at least, with 1% in mineral-type forms."

3. Denis Strachan:
   Silver reactors were cleaned using $Na_2S_2O_3$ (sodium thiosulfate). This material appears to have been sent to the tanks.

4. Used in bismuth-phosphate process

5. Dave Oestreich:
   Alkaline Cr+6 used extensively in closed cooling systems as corrosion inhibitor. Cr+6 is a powerful oxidizer. If Cr comes from dissolution of stainless steel, it is probably Cr+3. If Cr comes from decontamination operations (where oxidizing and reducing washes are used alternately), it is probably Cr+6.

6. Dan Herting:
   "Cr+3 and +6 both exist in the waste tanks, often in both forms in the same tank."

   "As a rule of thumb, you can assume that if it's in the liquid phase it's Cr+6, and if it's in the solid phase, it's Cr+3. (There won't be any Cr+2 at all, anywhere.) That assumption will be pretty accurate most of the time, except maybe for very high caustic tanks like 101-AW, where there could be some Cr+3 in the liquid phase (as the hydroxide complex ion)."

7. WHC-SD-EN-AP-078, Rev. 1:
   Known silica additions are assumed to have reacted with aluminates and hydroxides to form cancrinite (assumed to be 2NaAlSiO4 - 0 - 52NaNO3 - 0 - 6BH2O). [2NaAlSiO4 = sodium aluminosilicate?]

   Dan Herting:
   "Certainly not all of the added Si has formed cancrinite. There is still some in solution as sodium silicate, and there is an awful lot (in some particular SSTs) present as it was added, as

diatomaceous earth. [I prefer Na2SiO3 as the formula for sodium silicate, but the composition is variable (see Merck Index, sodium silicate).]"

8. Bill Winters:
TOC can be present in solid form because sodium salts of organic acids can form.

9. George Borsheim:
"The ferrocyanide precipitated in the FeCN tanks was predominantly Na2NiFe(CN)6, disodium nickel ferrocyanide. All of the nickel ferrocyanides are insoluble (so are a lot of other metal ferrocyanides), but nickel hydroxide is even more insoluble. I've attached a couple of pages from EP-0599 that shows how FeCN can decompose, you might want to get the whole document. I personally am not convinced that most of the FeCN solids contact OH- so that the solubilization can take place, but I may be wrong."

Dan Herting:
"Most people now believe that most of all of the FeCN has decomposed, and most of the resulting NaCN has hydrolyzed."

Joe Meacham:
"It is true that ferrocyanide poses a low toxicological risk because of it stability... The tanks are basic (pH>9) and presence of HCN is not likely. Ferrocyanide has undergone aging (i.e., hydrological and radiological degradation) in the Hanford Site SSTs. However, this does not result in the formation of free cyanide. The end result is the formatio of formate, ferric oxide, and ammonia:

$$Na2NiFe(CN)6(s) + 2\ NaOH \rightarrow Na4Fe(CN)6 + Ni(OH)2$$

$$6\ Fe(CN)6 + 12\ OH- + 66\ H20 + O2 \rightarrow 36\ HCOO- + 2\ Fe3O4 + 36\ NH3$$

It is unknown whether the ferrocyanide anion [Fe(CN)6] undergoes cleavage of a CN- ion before hydrolysis. However, aging experiments performed under gamma irradiation have shown little presence of free cyanide. Therefore, one can conclude that even if a free cyanide intermediate is formed, it is quickly destroyed by hydrolysis and the rate limiting step is cleavage.

In summary, free cyanide and HCN should not be present in the tanks and should not be addressed in tank farm releases."

Harry Babad:
"With the TAP's blessing, on THREE occasions, we have shown that:
1. HCN gas is not possible in alkaline tanks;

2. Radiolysis effects for CN destruction are orders of magnitude faster than for ferrocyanide as are the hydrolysis rates across all pH ranges. Reynolds has some data for NaCN and aqueous HCN, Borsheim and PNL both have, at various times, looked at the data (Lee Burger, Mike Lilga, Larry Pederson, and/or Randy Scheele)."

10. Denis Strachan
In the presence of strong base and CO_3^{2-} PO_4^{3-} increased solubility is expected. Results from the ferrocyanide Safety Program indicate that solid $Na_2NiFe(CN)_6$ and other Na-bearing cyanides no longer exist in the waste. However, $Cs_2NiFe(CN)_6$ appears to remain after hydrolysis of $Cs_2NiFe(CN)_6$. The quantities are very small.

11. Denis Strachan:
"I think we have to be a little careful here. there are data in WHC documents suggesting that CN- exists. Although most of our lab experience and our understanding of CN- chemistry suggests that CN- should have decomposed, we cannot rule its existence out. There should be a caveat on these data and suggest that the concentrations are very low."

Bill Winters:
"NaCN, I believe, could still exist in the tanks because of the large amounts of $Fe(CN)_6$ that was added. This compound may be disassociating in the waste, to form NaCN or some other metallic complex. However, it does not seem reasonable that uncomplexed cyanide (such as NaCN) would be present in the wastes because of hte large amounts of metals, Fe, Al, etc. However, I am not convinced all the cyanide would be hydrolyzed.

"Sam Bryant, PNL, may have some estimates of the fraction of free CN to FECN that could exist in the waste, or Bob Cas of the FeCN program may be able to direct you to someone doing speciation studies. The highest concentration of total cyanide I have seen have been 0.5 to 2.0 wt% in the ferrocyanide waste. However, I do not know what fraction could be free (NaCN) cyanide."

Denis Strachan:
"Relative to the NaCN issue - Karl Pool reports about 0.5 to 1% CN in the samples from C-112 (PNL-8858). Presumably this is $Na_2Fe(CN)_6$ as it agrees with the amount of CN needed for the Fe found in the samples.

"A couple of years ago, CN was reported in samples from SY-101. The

100s of ppm. There was some uncertainty in these data relative to interferences in the procedure used. However, it would seem that 500 ppm could be used as an upper bound for the NaCN. This number is purely speculation on my part. It should be checked against the numbers from Herting on the SY-101 analysis."

Bill Winters:

"There was a question of organic interferences in the 101-SY CN results. Organics such as sugar can react with nitrites and form CN during the acid distillation used for total CN determination. The 101-SY samples were rerun with sulfamic acid to destroy the nitrites and eliminate the interference. The rerun results were essentially the same as the original values. Sulfamate has been shown to be effective in removing these types of interferences providing an excess of the stoichiometric quantity is added."

12. Was used as hydrostatic fluid during sampling (practice discontinued).

Dan Herling:
"The contribution of hydrostatic drilling fluid to the NPH inventory of the tanks is vanishingly small. Virtually all of the NPH in the tanks came from the PUREX process. However, virtually of the the NPH <u>in the core samples taken from the tanks</u> came from the drilling fluid."

13. Denis Strachan:
Chevron Spray Base 450 and Shell Spray Base 60% nonaromatic cyclic products in early PUREX (also called naphthenes" in 1950s). Branched chain hydrocarbons were used in the late 50s and beyond. No good mechanism is known for making aromatic compounds from these hydrocarbons.

Harry Babad:
The early PUREX campaigns used a hydrogenated polycyclic mixture of hydrocarbons which contained perhydronapthylene also know as decalin (two 6-membered rings fused together), and other decalin alanogs such as a C5-C6 fused ring structure with a methyl group sticking out.

14. Dan Herling:
"The solubility of NH3 gas in the alkaline waste solution is currently a very hotly debated topic among the safety people. NH4NO3 has been found in some of the ventilation piping, but has never been found in solution. The pH is too high, even in the least alkaline tanks, to allow a significant amount of NH4+ ion to exist."

15. Denis Strachan:
"There are ample data from analysis of the organics in the wastes to suggest that these are present in analyzable quantities. Get in touch with Jim Campbell (PNL) to get a number for a tank like C-103."

"TBP and DBP would be found together since DBP is a hydrolysis product of TBP. I do not believe that these compounds will only be found in 'floating layers'. In the PUREX process the TBP is washed with caustic $KMnO_4$ which causes MnO_2 to precipitate. This MnO_2 can become coated with the organics (TBP/DBP). Therefore the organics could be associated with the solid phase - not just floating. MBP is the hydrolysis product of DBP and should be water soluble. It also may

hydrolyze to phosphate ion and butyl alcohol. I agree, Jim Campbell's analysis of C-103 might make a good worst case estimate of these compounds."

16. Can't exist in basic solution, so why does HASP list it?

Dan Herting:
"Formic acid should be listed as formate ion, COO-, due to the pH [formic acid cannot exist in tank waste, which is basic]. Little is known about how much of it exists in the tanks, but it certainly is known to be present."

17. H2S can't exist at high pH. Need to let HASP people know this.

Dan Herting:
"H2S is an acid, and definitely does not exist in the tanks. The sulfide anion might exist, but little is known about the chemistry of sulfide in the waste. Presumably, it does oxidize to sulfate. I might have thought, like DKO, that any sulfide present would precipitate; but just a couple weeks ago I did an experiment where I added Na2S to a waste tank supernate. The solution turned from pale yellow to dark brown (root beer colored), indicating formation of a sulfide complex ion with something in solution, but it did not precipitate."

Dave Oestreich:
"The color could well indicate formation of a colloidal precipitate. Many sulfides readily form colloids (especially at high pH). The color could also be from colloidal sulfur. (The sulfide could be oxidized by waste to sulfur."

18. HCN - although it is very volatile and toxic, it is an acid gas and can't exist at high pHs.

Dan Herting:
"HCN should not be listed at all. Can't exist under alkaline (tank) conditions."

19. Dan Herting:
"SO2 should not be listed at all. Can't exist under alkaline (tank conditions)."

Need to let HASP people know this.

20. Dan Herting:
"SO3 should not be listed at all. Can't exist under alkaline (tank) conditions."

Dave Oestreich:
"SO3 can't exist as a gas in solution; it forms sulfuric acid and neutralizes."

Need to let HASP people know this.

21. Dave Oestreich:
"HF can't exist at high pH."

Dan Herting:
"HF should not be listed at all. Can't exist under alkaline (tank) conditions."

Need to let HASP people know this.

22. Dave Oestreich:
Ag is a fission product.

Denis Strachan:
Silver was also used in silver reactors in PUREX for iodine removal from stack gases.

23. Denis Strachan:
Cobalt exists as a radioisotope but not as a bulk constituent.

24. Mercury is volatile, so it is in the headspace and plated out in ventilation systems. Have to consider that heavy metals accumulate in the plateout areas.

Dave Oestreich:
"Mercury may not be volatile if it is not present in the tanks as a metal."

Dan Herting:
"I haven't heard of any evidence that Hg has plated out in the ventilation system."

25. Dan Herting:
"Many metals like [Ni] (e.g., Be, Zn, Pb, Cd, Cr, Al, Sb, Mo) can exist in solution as the hydroxide complex ions if the hydroxide concentration is high enough. I recently reported characterization of tank 101-AW, which is relatively high in hydroxide (5-6 molar). In that tank, all of the metals listed in the parentheses above were mainly in the liquid phase as the hydroxide complex ions. For nickel, it would be something like [Ni(OH)4]-2."

26. Uranium daughter. Bill Winters: "Also used in fission production recovery operations - precipitated as PbSO4."

27. Dan Herting:
C2H3O3(-1) is glycolate ion, which is perhaps better written as HOCH2CO2(-1). C2H3O2(-1) is acetate ion, which could also be written H3C-CO2(-1) or CH3CO2(-1).

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APPENDIX A.2

LIST OF TOTAL ANALYTES WERE SCREENED

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To: Bill Cowley

From: Linda Fergestrom

Subject: Chemical constituents analyzed

Date: October 31, 1994

Summary and assumptions -

Chemical constituents on this list may be found reported as an ion or (where applicable) the element

Compounds found in the reports are also given

This is not a complete list, rather a good overview from looking at most of the sample tables

No radiological constituents are included on this list

All found chemical constituents

1,1,1-Trichloroethane	Acenaphthylene
1,1,2,2-Tetrachloroethane	acetate-
1,1,2-Trichloro-1,2,2-trifluoroethane	Acetone
1,1,2-Trichloroethane	Al - + +
1,1-Dichloroethane	Al2O3
1,2,4-Trichlorobenzene	AlO2-
1,2-Dichlorobenzene	AlOH--
1,2-Dichloroethylene	Anthracene
1,2-Dichloropropane	Antimony
1,3-Dichlorobenzene	Arsenic
2,4,5-Trichlorophenol	Barium
2,4-Dichlorophenol	Benzene
2,4-Dimethylphenol	Benzo(a)anthracene
2,4-Dinitrophenol	Benzo(a)pyrene
2,4-Dinitrotoluene	Benzo(b)fluoranthene
2,6-Bis(1,1-dimethylethyl)-4-methyl phenol	Benzo(ghi)perylene
2,6-Dinitrotoluene	Benzo(k)fluoranthene
2-Butanone	Benzoic acid
2-Chloronaphthalene	Benzyl alcohol
2-Chlorophenol	Beryllium
2-Hexanone	Bi + + +
2-Methylnaphthalene	Bis(2-Chloroethoxy)methane
2-Methylphenol	Bis(2-chloroethyl) ether
2-Nitroaniline	Bis(2-Chloroisopropyl) ether
2-Nitrophenol	Bis(2-ethylhexyl) phthalate
3,3'-Dichlorobenzidine	Boron
3-Nitroaniline	Bromodichloromethane
4,6-Dinitro-o-cresol	Bromoform
4-Bromophenylphenyl ether	Bromomethane
4-Chloro-3-methylphenol	Butylbenzylonthalate
4-Chloroaniline	C
4-Chlorophenylphenyl ether	C6H5O7---
4-Methylphenol	Ca(OH)2
4-Nitroaniline	Ca + +
4-Nitrophenol	Cadmium
Acenaphthene	Carbon disulfide

CCl4	Hexachlorobenzene			
Ca(NO3)2	Hexachlorobutadiene			
Ca+++	Hexachlorocyclopentadiene			
Chlorobenzene	Hexachloroethane			
Chloroethane	Hexadecanoic acid ester			
Chloroform	Hexamethyldisiloxane			
Chloromethane	Hexavalent Chromium			
Chrysene	hexone			
cis-1,3-Dichloropropene	Hg			
Cl-	Hydrogen			
CN-	I			
CO3--	Indeno(1,2,3-cd)pyrene			
Cobalt	Isophorone			
Cr+++	K+			
Cr2O3	KOH			
Cr2O7	La+++			
CrCl2	Li			
CrO4-	Magnesium			
Cs(NO3)2	Methoxytrimethylsilane			
Cu	Methylenechloride			
CuO	MgCl2			
Cyanide	MgO			
DBP	Mn++++			
Di-n-butylphthalate	MnO2			
Dibenz[a,h]anthracene	Mo			
Dibenzofuran	Na+			
Dibromochloromethane	Na2B4O7*10H2O			
Diethylphthalate	Na2CO3(H2O)			
Dimethyl phthalate	Na2CrO3			
Dodecane	Na2SiO3			
Dysprosium	Na2SO4			
Dy	Na3PO4(12H2O)			
EDTA--	Na4Fe(CN)6			
Ethylbenzene	NaAlO2			
Europium	NaF			
Extractable total organic halides	NaNO2			
F-	NaNO3			
Fe(CN)6---	NaNO4			
Fe++	NaOH			
Fe2O3	Naphthalene			
FeCl3*6H2O	Nd			
FeOH	Neodymium			
FeOOH	NH4 (Ammonia)			
Fluoranthene	Ni++			
Fluorene	NiSO4			
Gadolinium	N-Nitroso-di-n-dipropylamine			
glycolate-	N-Nitrosodiphenylamine			
H2O	Nitrobenzene			
HEDTA--	NO CO			

NO2-	Trimethylsilanol
NO3-	Tungsten
'a	Uranium
NPH	V
NTA---	Vinyl acetate
OH-	Vinyl chloride
oxalate--	Xylenes (total)
Pb + +	Yttrium
Pd	Zinc
Pentachlorophenol	Zr
Pentadecane	
Phenanthrene	
Phenol	
Phosphonic acid, dioctadecyl ester (8Cl,9Cl)	
Phosphorus	
PO4---	
Potassium	
Pu	
Pyrene	
Rare Earths	
Rh	
Ru	
Selenium	
Si	
Silver	
SiO2--	
SiO3	
SiO4	
Sn	
SO4--	
Sr(NO3)2	
Sr + +	
Styrene	
Ta	
TAD (Total Acid Demand)	
Te	
Tellurium	
Tetrachloroethene	
Tetradecane	
Thallium	
Thorium	
Ti	
TIC (Total inorganic carbon)	
TOC (Total organic carbon)	
Toluene	
Total carbon	
trans-1,3-Dichloropropene	
Trichloroethene	
Tridecane	

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APPENDIX A.3

INDEPENDENT REVIEW SUMMARY LETTERS

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Westinghouse
Hanford Company

Internal
Memo

From: 222-S Analytical Operations/Process Chemistry Labs 8E400N-94-001
Phone: 373-1951 T6-50/373-2532 T6-09
Date: June 23, 1994
Subject: REVIEW OF APPENDIX A IN DRAFT WHC-SD-WM-SARR-011

To: Janet S. Davis H4-64

cc: J.W. Daughtry H4-64
J.M. Grigsby H4-64
WIW File/LB
DLH File/LB

Reference: Davis, J.S., *Toxic Chemical Considerations for Tank Farm Releases*, Draft WHC-SD-WM-SARR-011, June 6, 1994.

The purpose of this memo is to document our review of Appendix A in the referenced document. We were asked to review the third column in the table, which lists chemical compounds formed by the given analytes in a typical waste tank environment (i.e., an alkaline environment created by addition of sodium hydroxide).

We provided several sets of comments, all of which were resolved. The resulting list of compounds is as complete and accurate as it can be given the lack of laboratory analytical data for chemical compounds in tank waste. We consider the list to be a good representation of chemical compounds likely to be present in the tanks.

If you have questions please call Bill Winters (373-1951) or Dan Herting (373-2532).

William I. Winters,
Fellow Scientist

Daniel L. Herting,
Senior Principal
Scientist

sz

Battelle
Pacific Northwest Laboratories
Battelle Boulevard
P.O. Box 999
Richland, Washington 99352
Telephone (509) 375-4464

November 28, 1994

Ms. Gail A. Chaffee (H4-61)
Westinghouse Hanford Company
PO Box 1970
Richland, WA 99352

Dear Ms. Chaffee:

ASSESSMENT OF CHEMICALS INCLUDED IN TOXICOLOGICAL REPORT

Thank you for the opportunity to review the list of chemicals that was included in the toxicological report (SARR-011) by J. S. Davis. Both Harry Babad and I reviewed the list that was produced at ICF Kaiser Hanford Company and the list shown in this document. Our comments have been sent to you under separate cover. The listing from Kaiser includes chemicals that we feel could not be present in tank wastes. Some of these chemicals probably are on the list as analytes because of the requirement to analyze these "listed" chemicals. Because the list that was given to us did not also list concentrations, it appeared to be simply a shopping list of chemicals that could be present in "listed" wastes. We also noted that most of the chemicals over which we had concern did not make into the above-mentioned document.

I hope that this letter, and our earlier communication, has been responsive to your needs. Please give us a call if there are any questions concerning our evaluation.

Sincerely,

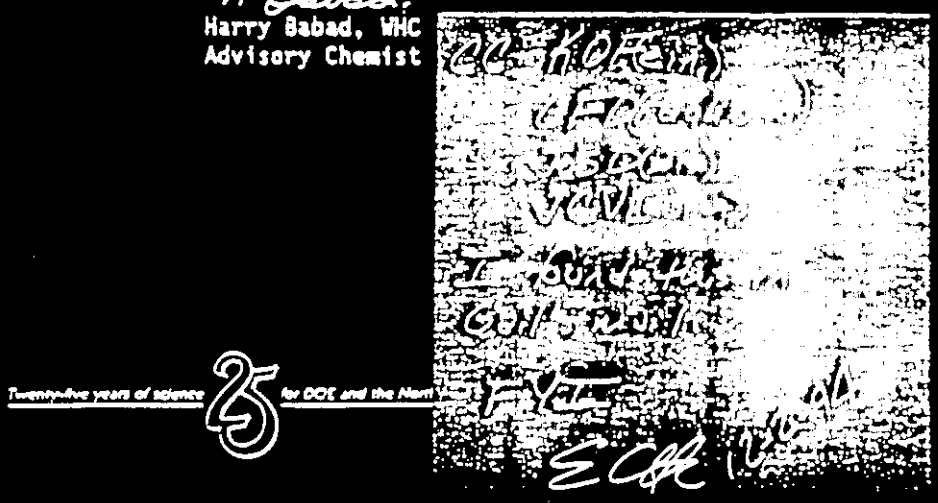
Strachan

Denis Strachan
Staff Scientist

Strachan for H Babad

Harry Babad, WHC
Advisory Chemist

DS/bjk



Battelle
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Battelle Boulevard
P.O. Box 999
Richland, Washington 99352
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December 7, 1994

Ms. Gail Chaffee (H4-61)
Westinghouse Hanford Company
PO Box 1970
Richland, WA 99352

Dear Ms. Chaffee:

CLARIFICATION OF OUR LAST TRANSMITTAL

In our last letter to you dated November 28, 1994, Harry Babad and I stated "We also noted that most of the chemicals over which we had concern did not make [it] into the above-mentioned document." By this statement we meant to indicate that the chemicals in the "shopping list" from ICF Kaiser Hanford Company did not appear in the toxicological report by J. S. Davis (SARR-011). These chemicals included those of petrochemical and pesticidal origin, which Harry Babad and I did not think ever got put into any of the waste tanks. We agree that these chemicals should not appear in the list of chemicals of toxicological concern in the toxicological report.

I am sorry for the confusion over that statement.

Sincerely,

Strachan

Denis Strachan
Staff Scientist

cc: H. Babad, WHC

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APPENDIX A.4

SAMPLE ANALYTE PLOT AND SUMMARY SHEETS

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APPENDIX B

GAS COMPOSITION DETERMINATION

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APPENDIX B.1

SUPPORTING DATA FOR HEADSPACE GASES — TOXICOLOGICAL EVALUATION OF ANALYTES FROM TANK 241-C-103

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PNL-10189
UC-607

Toxicologic Evaluation of Analytes From Tank 241-C-103

D. D. Mahlum, PhD
J. Y. Young, CIH
R. E. Weller, DVM

November 1994

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

Foreword

This document summarizes the collective contributions of the Toxicology Review Panel (TRP) in the evaluation of toxicologic implications of the analytes from Tank 241-C-103. Members of the TRP are as follows:

D. Dennis Mahlum, PhD (chair)
John Y. Young, MSPH, CIH (co-chair)
Antone L. Brooks, PhD
John A. Calcagni, MD
Jeffrey A. Dill, PhD
Barbara L. Harper, PhD, DABT
Thomas W. Henn, JD, MD
Mary F. Jarvis, PhD
James E. Morris, PhD
David L. Springer, PhD, DABT
Brian D. Thrall, PhD
Richard E. Weller, DVM

The TRP appreciates the proactive interest of the U.S. Department of Energy in the health and safety of workers in the Hanford tank farms. The TRP also wishes to acknowledge the excellent support provided by Steven C. Goheen, PhD, Program Manager, Pacific Northwest Laboratory (PNL), Jerry W. Osborne, Program Manager, Westinghouse Hanford Company (WHC), James L. Huckaby, PhD, WHC, and all the personnel involved in the Tank Vapor Sampling Program.

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7.1 Summary List of Targeted Chemicals for Toxicologic Evaluation as of August 6, 1994 . . . . . 7.2

Due to lack of consensus exposure standards for butanal and the NPHs, particularly dodecane and tridecane, the TRP determined that NPHs be treated as a group and that consensus exposure standards for dodecane and tridecane be set at 120 ppm, and a consensus exposure standard for butanal be set at 50 ppm.

The WHC Industrial Hygiene Group should develop an exposure assessment strategy that includes, at a minimum, area and personal sampling, hazard communication and training, medical monitoring, and record-keeping. Documentation of the exposure assessment strategy will be critical. Appropriate personal protection should be used by workers in the tank farm areas. This Group also should consider mitigation strategies to prevent potential release of these chemicals into the environment. Meteorological data should be continuously monitored when personnel are working in the immediate area of the tank or when exposure sampling is performed. A method for using sentinel compounds to monitor potential worker exposure is suggested.

The presence of many other compounds in addition to the target list should not be ignored; however, clarification of any biological effects will require additional efforts, as the potential toxicity of mixtures of chemicals cannot be accurately predicted from chemical characterization alone. Until actual biological characterization of tank vapors is performed, there will always be uncertainty about the contributions of unidentified constituents as well as the interaction of the chemicals on biological systems. The TRP recommends studies be undertaken to biologically characterize vapors from Tank 241-C-103 to ensure that they do not produce unexpected toxic effects. Initial screening studies can be performed in cellular systems, providing some indication of a hitherto unidentified component or interaction among components in a biological system.

Summary

Westinghouse Hanford Company requested PNL to assemble a toxicology review panel (TRP) to evaluate analytical data compiled by WHC, and provide advice concerning potential health effects associated with exposure to tank-vapor constituents. The team's objectives would be to 1) review procedures used for sampling vapors from tanks, 2) identify constituents in tank-vapor samples that could be related to symptoms reported by workers, 3) evaluate the toxicologic implications of those constituents by comparison to established toxicologic databases, 4) provide advice for additional analytical efforts, and 5) support other activities as requested by WHC. The TRP represents a wide range of expertise, including toxicology, industrial hygiene, and occupational medicine.

The TRP prepared a list of target analytes that chemists at the Oregon Graduate Institute/Sandia (OGI), Oak Ridge National Laboratory (ORNL), and PNL used to establish validated methods for quantitative analysis of head-space vapors from Tank 241-C-103. This list was used by the analytical laboratories to develop appropriate analytical methods for samples from Tank 241-C-103. Target compounds on the list included acetone, acetonitrile, ammonia, benzene, 1,3-butadiene, butanal, n-butanol, hexane, 2-hexanone, methylene chloride, nitric oxide, nitrogen dioxide, nitrous oxide, dodecane, tridecane, propane nitrile, sulfur oxide, tributyl phosphate, and vinylidene chloride.

Samples for analysis of vapors from Tank 241-C-103 were obtained via methods including OSHA versatile sampling (OVS) tubes (analyzed by PNL), SUMMA™ canisters (analyzed by OGI and PNL), and triple-sorbent tubes (TSTs; analyzed by ORNL). The semiquantitative data provided by these laboratories served as the basis for April 1994 TRP recommendations. In general, the compounds designated for further investigation met criteria stated in the Data Quality Objectives (DQO) document for Tank 241-C-103 (Osborne et al. 1994); namely, that when the concentration of a compound exceeds one-half of the consensus exposure standard for systemic toxins or one-tenth of the standard for carcinogens, mutagens, or teratogens, the WHC Industrial Hygiene Group is to be advised.

The TRP considered constituent concentrations, current exposure limits, reliability of data relative to toxicity, consistency of the analytical data, and whether the material was carcinogenic or teratogenic. A final consideration in the analyte selection process was to include representative chemicals for each class of compounds found.

The Tank Vapor Conference IV (Richland, Washington, March 8-9, 1994) resulted in improvements for sampling equipment and procedures. Sample Job 7B (SJ7B), was performed to quantitate the target analytes identified in the previous sampling, and to serve as the basis for a definitive evaluation of the toxicologic implications of vapors in Tank 241-C-103. Analysis of SJ7B revealed the same constituents as the previous sampling except no dodecane or tridecane were found, although n-tridecane was present. There was good agreement between the values obtained from the different laboratories using a variety of methods. The following conclusions were made:

Concentrations of acetone, hexane, nitric oxide, nitrogen dioxide, sulfur dioxide, butanal, and vinylidene chloride should not raise unacceptable toxicologic concern. Ammonia, nitrous oxide, tributyl phosphate, acetonitrile, n-butanol, 2-hexanone, propane nitrile, benzene, methylene chloride, NPHs, and 1,3-butadiene are present in concentrations large enough to warrant further consideration, although methylene chloride may be an artifact.

™ SUMMA is a trademark of Molectrics, Inc.

1.0 Introduction

A number of people have reported ill effects, including headaches, burning sensation in nose and throat, nausea, and impaired pulmonary function, while working around waste tanks on the Hanford Site. As indicated in the 1993 Program Plan for the Resolution of Tank Vapor Issues (Osborne and Huckaby 1994), musty and foul odors, including the smell of ammonia, have been reported to emanate from several single-shelled tanks. During the period between July 1987 and May 1992, 27 workers were involved in 16 complaints of exposures to odors. Ten of these occurrences, involving 18 workers, were linked to the C Tank Farm. In particular, Tank 241-C-103 was implicated in six of the reports, with 12 workers sustaining lost time. [For a brief history of Tank 241-C-103, see Mahlum and Young (1993).]

Westinghouse Hanford Company (WHC) requested Pacific Northwest Laboratory (PNL)[a] to assemble a toxicology team to independently review analytical data and provide advice concerning potential health effects associated with exposure to tank-vapor constituents. The team's objectives were to 1) review procedures used for sampling vapors from various tanks, 2) identify constituents in tank-vapor samples that could be related to symptoms reported by waste-tank workers, 3) evaluate the toxicologic implications of those constituents by comparison to established toxicologic data bases, 4) provide advice for additional analytical efforts, and 5) support other activities as requested by the project manager and the cognizant WHC Tank Vapor Issues Safety Resolution Manager.

A Toxicology Review Panel (TRP) was constituted during FY 1993 to help with these objectives. In particular, the TRP was to identify and recommend compounds of toxicologic concern for quantitative analysis by validated methodology, with the quantitation extending to levels well below established exposure standards. The panel is composed primarily of staff from PNL's Life Sciences Center, and occupational medical doctors from the Hanford Environmental Health Foundation (HEHF). The TRP was designed to represent a wide range of expertise, including analytical chemistry, industrial hygiene, occupational medicine, genetic and general toxicology, immunology, and radiation biology.

The TRP was requested by WHC and Northwest Instrument Systems Inc. (NISI) to prepare a list of analytes that chemists at Oregon Graduate Institute/Sandia (OGI), Oak Ridge National Laboratory (ORNL), and PNL could use to establish validated methods for quantitative analysis of head-space vapors from Tank 241-C-103. The TRP also was asked to recommend the levels at which the laboratories should be able to analyze the compounds. A preliminary list was developed using two sets of existing data, one each from analyses performed by PNL and OGI. Although these previous samplings and analyses were obtained using nonvalidated methodology, both sets of data showed the presence of n-butanol, acetone, acetic acid, normal paraffin hydrocarbons (NPHs) with their alcohol and ketone derivatives, aromatic hydrocarbons, and several chlorinated hydrocarbons. In addition, the PNL data indicated the presence of significant concentrations of ammonia, tributyl phosphate, and nitrogen oxides in the head-space vapor. A list of analytes was prepared based on 1) the concentrations reported

(a) Pacific Northwest Laboratory is a multiprogram national laboratory operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

by PNL and OGI, 2) the toxicity of the compounds (especially if potential carcinogenic activity was reported for a compound), and 3) the need to solidify the data on potential classes of compounds. This list was used by the analytical laboratories to begin development of appropriate analytical methods in preparation for receipt of samples from Tank 241-C-103 that would be provided by WHC.

2.0 TRP Activities in FY 1994

Samples for analysis of vapors from Tank 241-C-103 were obtained by WHC using a number of sampling methods including Occupational Safety and Health Administration (OSHA) versatile sampling (OVS) tubes, SUMMA™ canisters, and triple-sorbent tubes (TSTs). A sampling performed in December 1993 and January 1994, Sample Job 6B (SJ6B), provided data for an initial TRP review in April 1994. The OVS tubes were analyzed by PNL, the SUMMA™ canister samples by OGI and PNL, and the TSTs by ORNL. The analyses of ammonia, nitrogen oxides, and sulfur oxides also were performed by PNL.

The semiquantitative data provided by these laboratories were presented at Tank Vapor Conference IV, Richland, Washington, March 8-9, 1994, and served as the basis for the April 1994 TRP recommendations. These recommendations consisted of a list of constituents for which quantitative methods were to be established and validated (April 13, 1994, letter from S.C. Goheen to J.W. Osborne); many constituents were the same as suggested in the preliminary list mentioned previously (Mahlum and Young 1993). In general, the compounds designated for further investigation met criteria stated in the Data Quality Objectives (DQO) document for Tank 241-C-103 (Osborne et al. 1994). The DQO specifies that when the concentration of a compound exceeds one-half of the consensus exposure standard for systemic toxins or one-tenth of the standard for carcinogens, mutagens, or teratogens, the WHC Industrial Hygiene Group is to be advised. This stipulation helps guide the group in selecting methods for area and personnel monitoring on the tank farms.

The TRP considered constituent concentrations, current exposure limits, reliability of data relative to toxicity, consistency of the analytical data, and whether the material was carcinogenic or teratogenic. A final consideration in the analyte selection process was to include representative chemicals for each class of compounds found. The result is that representatives for NPHs, nitriles, ketones, aldehydes, halogenated hydrocarbons, alcohols, aromatics, and inorganics were included on the list. Sulfur oxides were added to the list because earlier data had suggested their presence. From the list of analytes reported from SJ6B, the TRP selected the materials shown in Table 2.1.

In addition to the analytical data presented, attendees at Tank Vapor Conference IV identified improvements to be made in the sampling equipment and procedures. Subsequently, two additional samplings (Sample Jobs 7A and 7B) were performed on Tank 241-C-103. Sample Job 7B (SJ7B) was performed to quantitate the target analytes identified from SJ6B, and to serve as the basis for a definitive evaluation of the toxicologic implications of vapors in Tank 241-C-103.

The data from SJ7B have been summarized (Table 3.1) by Huckaby and Story (1994). The results were presented and discussed at Tank Vapor Conference V on July 18 and 19, 1994, in Richland, Washington. The TRP has used these data for the evaluation presented in this report.

Table 2.1. Analytes from Tank 241-C-103 Recommended for Quantitation

Compound	CAS	Exposure Limits (ppm)						CES*	Health Effects
		NIOSH REL		ACGIH TLV		OSHA PEL			
		8-hr TWA	STEL	8-hr TWA	STEL	8-hr TWA	Other		
Acetone	67-64-1	250		750	1000	1000			Narcosis; CNS depression; eye, nose, throat and skin irritation
Acetonitrile	75-05-8	20		40	60	40			Brain tumors; lung and bowel cancer
Ammonia	7664-41-7	25	35	25	35	50			Respiratory and eye irritation
Benzene	71-43-2	0.1/LOQ	1 (c) (15 min)	0.1** (A2)		10/25 (c)	50(10min)(p)		Leukemia
1,3-Butadiene	106-99-0	0.19/LOQ		2** (A2)		1000			Hematopoietic cancer; teratogenic and reproductive effects
Butanal	123-72-8							50	Eye, nose, throat, and skin irritant. Insufficient information on chronic effects
n-Butanol	71-36-3	50 (c)(s)		50 (c)(s)		100 (s)			Eye and mucous membrane irritation; CNS depression
Hexane	110-54-3	50		50		500			Skin and nervous system effects
2-Hexanone (MeBK)	591-78-6	1		5 (s)		100			Irritation; liver, kidney, and nervous system effects
Methylene chloride	75-09-2	LOQ		50 (A2)		100			Potential for cancer; tumors of the lung, liver, salivary, and mammary glands in animals
Nitric oxide	10102-43-9	25		25		25			Effects on blood and respiratory system
Nitrogen dioxide	10102-44-0	1	2	3			1 (c)		Respiratory and blood effects
Nitrous oxide	10024-97-2		25***	50		500/1000 (c)	2000(5 min in 2 hr)(p)		Reproductive system effects and decrease in audiovisual performance
Dodecane	112-40-3							120	Skin and nervous system effects
Tridecane	629-50-5							126	Skin and nervous system effects
Propane nitrile	107-12-0	6							Hepatic, renal, respiratory, cardiovascular, gastrointestinal, and nervous system effects
Sulfur oxide	7446-09-5	2	5	2	5	5			Respiratory effects
Tributyl phosphate	126-73-8	0.2		0.2		0.66			Pulmonary irritation; moderate excitation of nervous system in animals
Vinylidene chloride	75-35-4	0.4/LOQ		5	20				Potential for cancer; liver and kidney tumors in animals

* No established exposure limit; CES values as proposed by TRP
** Proposed for intended changes
*** For the duration of exposure
A2 Suspected human carcinogen
(c) Ceiling
(s) Skin designation
(p) Peak concentration
ACGIH TLV American Conference of Governmental Industrial Hygienists threshold limit value
CAS Chemical Abstracts Service
CES Cerenkov exposure standard
LOQ Limit of quantitation. For carcinogenic materials, NIOSH recommends LOQ as the desired limit.
NIOSH REL National Institute for Occupational Safety and Health recommended exposure limit
OSHA REL Occupational Safety and Health Administration permissible exposure limit
Sources: Title 29 CFR 1910
ACGIH 1993
NIOSH 1977, 1992

3.0 Discussion of SJ7B Data

The data in Table 3.1, in general, show fairly good agreement between values from different laboratories for those materials collected and analyzed by more than one method. This agreement gives confidence that the data closely reflect the actual content of the tank. This confidence is further strengthened by the similarity in results obtained for NPH from OVS tubes lowered into the tanks and from samples of the vapor sampling system. These results also suggest that both the sampling procedures and the analytical procedures are being well-controlled.

The concentrations of several constituents fell below the level of concern defined previously. Acetone, hexane, nitrogen oxide, nitrogen dioxide, and sulfur oxides did not exceed one-half of the exposure standard for systemic toxins, and the level of vinylidene chloride fell below one-tenth of the exposure standard. The other compounds on the list, however, are in sufficient concentrations that they merit continued consideration. Concentrations of ammonia, nitrous oxide, and tributyl phosphate all exceeded the actual exposure standards, while values for acetonitrile, n-butanol, 2-hexanone, and propane nitrile were greater than 50% of the exposure standards. These compounds should be considered by WHC management and industrial safety staff relative to the selection of methods for area and personnel monitoring, personal protective equipment, and mitigation strategies on the tank farms. Although values for benzene, 1,3-butadiene, and methylene chloride were very low, they are considered carcinogens and exposure should be minimized. Methylene chloride was used to clean the sampling equipment; therefore, the levels found may not be due to material in the tank but to extremely low residual levels in the sampling apparatus.

A third group of materials includes the NPHs (dodecane and tridecane) and butanal (butyraldehyde), for which no exposure standards have been established. However, the TRP considered exposure standards for similar compounds to recommend levels of potential concern by analogy. For example, the recommended exposure limits (RELs) for heptane, octane, and nonane are 85, 75, and 200 parts per million (ppm), respectively. An average of the RELs for these three materials is 120 ppm; combining values for dodecane and tridecane would result in a value greater than 50% of the average, suggesting that attention should be given to the NPH as a class.

Because butanal also does not have an established exposure limit, we examined exposure limit values for similar types of compounds, i.e. other short-chain aldehydes. Data for propanal, pentanal, and hexanal were examined because they constitute the homologous compounds on each side of the compound of interest.

Values for the lethal dose for 50% of the experimental animals (LD_{50}), a gross measure of toxicity, are similar for propanal, butanal, and pentanal. The oral LD_{50} values of approximately 5 g/kg body weight are indicative of low acute toxicities. When the materials are administered at toxic levels, all three produce mild central nervous system depression. All the chemicals have been reported negative in tests for mutagenicity (Sax and Lewis 1989). Thus, the three compounds appear to be similar in their toxicologic properties. Although there is no established exposure limit for propanal, an REL of

Table 3.1. Data from Sample Job 7B for Compounds of Toxicologic Concern from Tank 241-C-103

Chemical (CAS#)	Reported Concentration (ppm)	IDLH (ppm)	IDLH Concern	1/2 or 1/10 CES* (ppm)	Retain on List
Acetone (67-64-1)	19.2 -19.4 8.8	20,000	no	125	no
Acetonitrile (75-05-8)	12.7 - 13.2 9.1	4,000	no	10	yes
Ammonia (7664-41-7)	304	500	maybe	12.5	yes
Benzene** (71-43-2)	<0.01 - 0.33 0.08	1,000	no	0.01	yes
1,3-Butadiene** (106-99-0)	<0.05 - 0.06	20,000 (LEL)	no	0.019	yes
Butanal (123-72-8)	4.4 - 4.7 1.2		?	25	no
n-Butanol (71-36-3)	13.1 28.4	8,000	no	25	yes
n-Dodecane (112-40-3)	36.2 - 46.4 40.3		?	60	yes***
n-Hexane (110-54-3)	0.71 - 0.72 0.8	5,000	no	25	no
2-Hexanone (591-78-6)	0.57 - 0.59 0.51	2,000	no	0.1	yes
Methylene chloride** (75-09-2)	<0.02 - 0.061 1.62	5,000	no	5	yes
Nitric oxide (10102-43-9)	1.5	100	no	12.5	no
Nitrogen dioxide (10102-44-0)	<0.06	50	no	1.5	no
Nitrous oxide (10024-97-2)	763		?	12.5	yes
Propane nitrile (107-12-0)	5.1 - 5.3 3.3		? ?	3	yes
Sulfur dioxide (7446-09-5)	<0.02	100	no	1	no
Tributyl phosphate (126-73-8)	0.51	125	no	0.1	yes
n-Tridecane (629-50-5)	40.1 - 63 52		?	60	yes***
Vinylidene chloride** (75-35-4)	<0.02 <0.009		?	0.02	no

* Adopted from the most stringent or available exposure standards/guidelines
** Use 1/10 of CES because of carcinogenicity, teratogenicity, and mutagenicity
*** Counted as a part of NPH, potential exposure to total NPH is expected to exceed 1/2 of CES
CAS - Chemical Abstract Service
CES - Consensus exposure standard
IDLH - Immediately dangerous to life and health
LEL - Lower explosion limit

50 ppm has been established by the National Institute for Occupational Safety and Health (NIOSH) for pentanal. Because of the similarities between butanal and pentanal, the TRP recommends using the pentanal value of 50 ppm for butanal.

Table 3.1 also provides a list of available immediately dangerous to life and health (IDLH) values for the target analytes, as reported by NIOSH (NIOSH 1990). The IDLH values represent "the maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes and without experiencing any escape-impairing (e.g., severe eye irritation) or irreversible health effects." NIOSH established these values only for the purpose of respirator selection. Reported concentrations on ammonia in Tank 241-C-103 are found to approach the IDLH value (greater than one-half of IDLH), but the other target analytes were well below their respective IDLH values. This indicated that ammonia from Tank 241-C-103 may present a potential IDLH concern under a worst-case scenario. The listing of IDLH values in Table 3.1 for carcinogenic compounds such as benzene, 1-3-butadiene, or methylene chloride is only for informational purpose. One must never allow exposure of personnel to carcinogens to the extent which the ambient concentrations could ever reach the IDLH levels.

3.1 Odor Thresholds

Workers in the various tank farm areas consistently reported the presence of odors. There has even been an effort to have a reporting system for workers to report odors to HEHF. Certainly, in some cases, the presence of an unusual odor or more intense level of odors routinely encountered may be useful in recognizing abnormal conditions. However, odorous chemicals may not always offer the needed warning to workers after they are in the area. Use of odors to identify hazard, or its absence, can lead to a false sense of security, because odor recognition and detection are very subjective (see Table 3.2), especially when the material responsible for the odor has not been identified. Moreover, the reported concentrations in the head-space vapor of Tank 241-C-103 (Table 3.2) may be much lower than the range of the odor thresholds for most of the target analytes. Individuals vary in their sensitivity to different odorants. A person may be anosmic to one odor and yet hyperosmic to the odor of another similar compound. Such variation occurs in specific anosmia and often is developed by repeated exposure to a particular chemical. Another concern is the problem with olfactory fatigue, which can set in quickly when the person has been exposed for a period of time. All of these can occur in tank farm workers who may have daily exposure to odors of several chemicals. One needs to exercise caution in using the odor thresholds, and take into account in the assessment the presence of chemicals in the ambient air in the work place.

3.2 Rationale for Using LD_{50} and LC_{50} to Evaluate Toxicity Potentials

Lethal dose 50% and lethal concentration 50% (LC_{50}) information was used to estimate toxicities of various aldehydes and nitriles. The DQO document for Tank 241-C-103 discusses several approaches to be used when there is not an established exposure limit for a compound. Databases are to be queried for information about the material of interest, e.g., butanal, as well as for information for analogous compounds, such as propanal, pentanal, and hexanal. Various measures of toxicity, including mutagenicity, developmental effects, carcinogenicity, and systemic effects were examined. Values for LD_{50} and LC_{50} are commonly used endpoints in initial toxicity assays (Sax and Lewis 1989).

Table 3.2. Odor Thresholds and Descriptions on Tank 241-C-103 Target Analytes

Chemical	Odor Threshold (ppm)			Odor Description	Warning Properties
	Detection	Recognition	Inclusive Range		
Acetone	62	130	0.4 - 800	sweet/fruity	good
Acetonitrile	1160		[illegible]	etherish	poor
Ammonia	2		[illegible]	pungent/irritating	good
Benzene	61	97	0.78 - 160	aromatic/sweet	poor
1,3-Butadiene	0.45	1.1	0.099 - 76	aromatic/rubber	good
Butanal					
n-Butanol	2	5.8	0.15 - 990	sweet/alcohol	good
[illegible]					
n-Hexane			65 - 248	gasoline	poor
[illegible]			0.068 - 0.085	sweet/plastic	good
Methylene chloride	160	230	192 - 440	sweet	poor
Nitric oxide					
Nitrogen dioxide			0.053 - 0.14	bleach	good
Nitrous oxide					
Propane nitrile	136		[illegible]	onion/garlic	good
Sulfur dioxide	2.7	4.4	0.33 - 5	metallic taste/sharp irritating	good
Tributyl phosphate					
[illegible]					
Vinylidene chloride	190			sweet	poor

Sources: American Industrial Hygiene Association 1989.
Lewis 1993.
Mine Safety Appliances Company 1994.
NIOSH 1990.

These values often are used as the starting point for establishing exposure standards such as the threshold limit values (TLVs) (ACGIH 1991, 1993). Therefore, the TRP believes that it is appropriate to examine LD_{50} or LC_{50} values when exposure limits have not been adequately established. However, the TRP recommends that the LD_{50} and LC_{50} must be used with discretion, because the interpretations of these values may be limited by many factors, including route and rapidity of administration, and physiologic status and gender of the experimental animals used. Thus, LD_{50} and LC_{50} values were used as one basis to estimate appropriate exposure levels.

4.0 Toxicologic Implications of Tentatively Identified Chemicals

In addition to the analytical information on the compounds recommended by the TRP, Huckaby and Story (1994) also listed in Appendix A of their report some 246 tentatively identified compounds. This extensive list indicated the extremely complex nature of the head-space vapor from Tank 241-C-103. However, there are many uncertainties associated with the identity and concentration of the listed compounds; most were identified on the basis of their retention time and signature recognition (matches and fits) from library spectra typically used in gas chromatography-mass spectrometry (GC-MS). A number of these compounds were either double or multiple entries, and many were listed as mixtures; most were present in relatively low concentrations relative to established exposure standards. Moreover, the complexity of the mixture and the uncertainty of the identifications made it impractical to assess the actual contribution of each of these materials to the potential toxicity of the vapors. Thus, the efforts of the analytical laboratories and the industrial health and safety resources were focused on those chemicals that were deemed to represent the greatest potential for producing toxicologic effects. Working with WHC staff and their consultants during the past year, the TRP reviewed existing analytical data and produced a preliminary list of chemicals of potential toxicologic concern based on concentrations, toxicity, and consistency of data. After a series of evaluations by the TRP, a more refined list of chemicals for analytical validation and further toxicologic evaluation was produced as described previously.

The presence of many other compounds should not be ignored; however, clarification of any biological effects will require additional efforts, because the potential toxicity of mixtures of chemicals cannot be accurately predicted from chemical characterization data alone. It has been shown with a number of complex organic mixtures from tobacco smoke and synthetic fuel processes that the biological effects produced are markedly different from those predicted from the chemical analysis. However, these same studies have shown that mixtures can be biologically characterized using both simple cellular and whole-animal systems.

Until actual biological characterization of tank vapors is performed, there will be uncertainty about the contribution of unidentified constituents as well as the interaction of the chemicals on biological systems. Therefore, the TRP recommends that studies be undertaken to biologically characterize vapors from Tank 241-C-103 to ensure that they do not produce unexpected toxic effects. Initial screening studies could be performed in cellular systems, providing some indication of a hitherto unidentified component or interaction among components in a biological system.

5.0 Applicable Industrial Hygiene Considerations

An important application that follows the toxicologic evaluation of chemicals in the tank head space is to provide the WHC Industrial Hygiene Group some basis on which to formulate an exposure-assessment strategy (Hawkins et al. 1991). This will be useful to evaluate and control workers' potential exposure to chemicals from working at Tank 241-C-103. The TRP recommends the following considerations in the design of an industrial hygiene exposure-assessment program.

5.1 Sample Selected Chemicals

For short-term, nonroutine work activities such as those found in the tank farm, WHC Industrial Hygiene personnel should consider sampling for selected chemicals for the duration of the work period. Compounds of interest may include acetonitrile, ammonia, benzene, nitrous oxide, and NPHs. Quantitative assessment should be sought to better define the exposure risk, to evaluate and ensure workers' protection and regulatory compliance, and to verify the efficacy of available control measures.

5.2 Evaluate Exposure Standards

Chemicals with limits of quantitation (LOQ) values given for their RELs warrant attention. For example, new information has become available on 1,3-butadiene as NIOSH updated the exposure limit to 0.19 ppm (LOQ), while the OSHA permissible exposure limit (PEL) (Title 29 CFR 1910) for 1,3-butadiene remains at 1000 ppm. Industrial hygienists need to evaluate all available information to determine which exposure standard to use, keeping in mind that workers' protection must be the first and foremost criterion. This approach particularly applies to benzene, 1,3-butadiene, and methylene chloride.

5.3 Share Information

Data on the sampling results and toxicity of constituents must be provided to the workers. This should alleviate workers' concern about potential exposure hazard, and will help them understand the importance of prescribed control measures, such as the use of special procedures and/or personal protective clothing. This information-sharing should be part of hazard-communication training, with documentation and, if necessary, follow-up on-the-job training. Sampling results also must be communicated to the medical staff for both medical surveillance and targeted personal medical monitoring.

5.4 Protect Against (Skin-Designated) Chemicals

Exposure standards for chemicals such as n-butanol and 2-hexanone carry a "skin" designation in the exposure standards. This designation refers to the potential significant contribution to the overall exposure by the cutaneous route. When potential exposure to the skin-designated chemicals is anticipated, it is advisable to require workers to cover all exposed skin. The choice of gloves for skin

protection will be important if personnel need to handle parts that are contaminated with the chemicals. One should consult various publications regarding chemical protective clothing. Consider the following examples:

- *Chemical Protective Clothing*, a two-volume textbook published by the American Industrial Hygiene Association (AIHA)
- *Guidelines for the Selection of Chemical Protective Clothing*, a two-volume field reference manual published by the American Conference of Governmental Industrial Hygienists
- Manufacturers' publications, such as *Best's Guide to Chemical Resistant Best Gloves*.

In terms of sampling for personnel exposure, "sniff" sampling may be performed on work equipment and other work surfaces (Ness 1991), particularly for skin-designated chemicals. Sniff sampling using detection devices such as the portable gas chromatograph with flame ionization detector or photo-ionization detector (GC-FID/PID) will be useful. These detection devices do not usually distinguish individual compounds, and therefore only provide qualitative results. However, a GC-FID/PID is an excellent tool to determine whether contamination is present or decontamination is effective. Sniff sampling should target compounds such as n-butanol and 2-hexanone.

5.5 Consider Ambient Conditions that May Affect Personnel Exposure

To evaluate workers' exposure in outdoor work (as it is typically found in the tank farm areas), it is important to consider the meteorological data or ambient conditions in the periods during which exposure sampling is conducted. In general, the magnitude of exposure is dependent upon the distance or proximity of the workers from the source of chemical release. Dispersion of chemical vapors or aerosols depends on wind speed and directions, barometric pressure, ambient temperature, and relative humidity. Terrain features and existing barriers in the local area around the tank farm also can affect the dispersion patterns of the airborne chemical contaminants. One needs to recognize the importance of meteorological conditions in order to evaluate workers' exposure and to include these conditions in the decisions for workers' protection. It is also important to note that meteorological conditions may change during a work period, such that the meso-scale (immediate area) meteorological conditions should be monitored continuously.

6.0 Sentinel Compounds

The data used for toxicologic evaluation were obtained from the head space of Tank 241-C-103. These data thus represent the highest concentrations that would be encountered in the work place. From a pragmatic point of view, it would be desirable to measure levels in the breathing zone of workers around the tank. Attempts at such measurements by the WHC Industrial Hygiene Group have generally shown little or no apparent material being present. Releases of vapors from the head space seem to occur sporadically, so unless the measurements coincided with releases, failure to detect vapor components would be likely. However, if releases occur, the concentrations of the various components of the vapor are likely to be significantly lower in the vicinity of the workers' breathing zone than in the head-space vapor itself.

Materials for which the maximum concentration in the head space is near the limit of detection (for example, 1,3-butadiene and vinylidene chloride) pose special challenges for the industrial hygienist trying to measure their concentrations in the work place. Therefore, these compounds may be difficult to retain on a list of compounds of toxicologic concern. Yet, they are considered carcinogens by NIOSH and thus, the RELs are essentially the LOQ, even though exposure standards set by other groups may be significantly higher. The concentration of benzene in the vapor is also low and difficult to detect in the breathing zone of workers around Tank 241-C-103.

To ensure that carcinogenic compounds in very low concentrations are not missed, a limited number of chemicals (perhaps three) should serve as sentinel compounds to be monitored routinely. Compounds should be selected based on their relatively high concentrations in the head space and their ability to be easily detected in the event of a release. If these sentinel compounds are detected in the working area at concentrations above an action level, one would assume that other toxic materials which are present proportionately at lower levels in the head-space vapor also are being released at levels of concern; specific sampling targeted to other toxic materials may be necessary. In general, actions to protect against these sentinel compounds would also protect against the other toxic materials. For example, ammonia, nitrous oxide, and tridecane are found at relatively high concentrations and can be easily measured. Monitoring for these materials in the work place could be accomplished easily and actions taken if the levels exceed an established warning level. Taking measures to protect against undue exposures to these compounds should then prevent undue exposures to other compounds of toxicologic concern that have been identified in the head-space vapor. This approach would seem to offer a practical and economic way to protect workers while allowing the necessary work to be performed.

An example might serve to illustrate how such a system might work. For simplicity, the following example considers only two materials, a sentinel compound and a carcinogen. The concentration of ammonia in the head space is about 300 ppm and that of benzene is 0.33 ppm. For this example, we have used the short-term exposure limit for benzene to illustrate the possible use of a sentinel compound because there is no expectation that workers would be working for 8 hr/d where releases were occurring. The short-term (15-min) exposure limit for benzene is 1.0 ppm. Thus, following the procedure specified in the DQO, a level of 0.1 ppm (0.1 x short-term exposure limit) would be considered as an action level. Concentrations as low as 0.1 ppm outside of the tank would have to be detected, a difficult level to measure. However, if we assume that the ratio of benzene to ammonia in the breathing zone outside of the tank is the same as in the head space, we can arrive at a level of ammonia that would serve as a warning for benzene. The concentration of benzene would need to be

3.3-fold less outside of the tank than it is inside in order to meet the 0.01-ppm designated level (0.33 ppm/3.3 = 0.1). Thus, a concentration of ammonia in the breathing zone 1/3.3 of that in the head space, or 90 ppm, should be indicative of a benzene level of 0.1 ppm, warning that action should be taken. However, the short-term exposure limit for ammonia is 35 ppm, so even if that value is met, the exposure to benzene would be less than 40% of the 0.1-ppm limit. Because prolonged exposure to ammonia would be limited to one-half of its TLV of 12.5 ppm, even long-term benzene exposure wouldn't exceed 0.01 ppm [0.1 x 0.1 ppm, the REL for 8-hr time-weighted average (TWA)]. Thus, using a sentinel compound such as ammonia would still offer a high degree of protection while permitting detection of releases into the work place.

Table 6.1 compares the use of ammonia, nitrous oxide, and tridecane as sentinel compounds for benzene and 1,3-butadiene. The calculations used in the table show that, for Tank 241-C-103, benzene would serve as the driving force for determining the level of sentinel compound(s) at which protective action would be taken. It can also be seen that these levels are influenced by both the level of the carcinogen of interest and the compounds being considered as sentinels.

From a practical standpoint, sentinel compound sampling will save time and resources for evaluation of workers' exposure. One needs to understand that sentinel sampling does not and should not preclude baseline and periodic sampling as required by OSHA regulations. Sentinel sampling can be done after a baseline for all the target chemicals present has been established within some level of confidence. We merely suggest that when confidence has been established on the expected concentrations and ratios among the various target chemicals, one may choose to sample fewer compounds that can represent the presence of the others. A baseline may change in time as work procedures may change, or exposure conditions may be improved either by engineering controls or mitigation/reduction of the hazards. At that time, a new baseline sampling may be performed. Periodic sampling to verify the validity of the current baseline should be performed from time to time.

Table 6.1. Use of Sentinel Compounds to Monitor for Carcinogens in Vapor from Tank 241-C-103

			Sentinel Conc. Equiv.** to 0.1 TLV for Carcinogen		
Carcinogen	Conc. in C-103* (ppm)	0.1 TLV (ppm)	Ammonia	N_2O	Tridecane
Benzene	0.33	0.1***	90	230	15
1,3-Butadiene	0.06	0.02	109	277	18.5

* Highest reported concentrations from Sample Job 7B

** Based on concentrations in Tank 241-C-103 head-space vapor of 300, 763, and 52 ppm for ammonia, nitrous oxide, and tridecane, respectively.

*** Based on 15-min short-term exposure limit for benzene

7.0 Conclusions

Acetone, hexane, nitric oxide, nitrogen dioxide, and sulfur dioxide do not exceed one-half of their respective consensus exposure standards. Although there is no such standard for butanal, the butanal concentrations do not exceed the consensus exposure standards for pentanal, a similar compound. The concentration of the carcinogen vinylidene chloride does not exceed one-tenth of its consensus exposure standard. These compounds should not raise unacceptable toxicologic concern.

The concentrations of ammonia, nitrous oxide, tributyl phosphate, acetonitrile, n-butanol, 2-hexanone, propane nitrile, benzene, methylene chloride, NPHs, and 1,3-butadiene are greater than one-half of the REL for noncarcinogens or greater than one-tenth of the REL for carcinogens. Therefore, they should receive continued consideration. Methylene chloride may be a sampling and analysis artifact; further clarification is needed from the laboratories before this compound can be ruled out.

Due to lack of consensus exposure standards for butanal and NPHs, particularly dodecane and tridecane, rationale has been given to treat the NPHs as a group and to set a consensus exposure standard for dodecane and tridecane at 120 ppm.

For those compounds that merit continued consideration, the TRP believes that an exposure assessment strategy should be developed that includes, at minimum, area and personal sampling, hazard communication and training, medical monitoring, and record-keeping. Documentation of the exposure assessment strategy will be critical. In the absence of sufficient engineering or administrative controls, appropriate personal protection shall be used for personnel working in the area. The industrial safety staff should also consider mitigation strategies to prevent potential release of these chemicals into the environment.

Meteorological data should be continuously collected when personnel are working in the immediate area or when exposure sampling is performed. The ambient conditions may change during a given work period. Such changes may influence decisions on workers' protection in the tank farm areas.

A method for using sentinel compounds to monitor potential worker exposure is suggested.

Biological characterization of the vapors is recommended.

The following is a revised list of chemicals targeted for toxicologic evaluation (as of August 6, 1994), and includes Chemical Abstract Service (CAS) references (see Table 7.1):

- Acetonitrile (CAS 75-05-8)
- Ammonia (CAS 7664-41-7)
- Benzene (CAS 71-43-2)
- 1,3-Butadiene (CAS 106-99-0)
- n-Butanol (CAS 71-36-3)

- 2-Hexanone (CAS 591-78-6)
- Methylene chloride (CAS 75-09-2)
- Nitrous oxide (CAS 10024-97-2)
- NPHs (dodecane and tridecane) (CAS 112-40-3 & 629-50-5)
- Propane nitrile (CAS 107-12-0)
- Tributyl phosphate (CAS 126-73-8).

Table 7.1. Summary List of Targeted Chemicals for Toxicologic Evaluation as of August 6, 1994

Compound	CAS	Sample Type	Reported Concentration (ppmv)	CES (ppm)		CES Sources	Expected Health Effects
				8-hour TWA	STEL		
Acetonitrile	75-05-8	SUMMA TST	19.3 - 19.4 5.3	20	50	x, y	Brain tumors: lung and bowel cancer
Ammonia	7664-41-7	Sorbent Trap	30.4	25	35	z, y	Respiratory and eye irritation
Benzene (A2)	71-43-2	SUMMA TST	<0.01 - 0.33 0	0.1/LQQ	1 (c) (15 min)	z, y	Leukemia
1,3-Butadiene (A2)	106-99-0	SUMMA	<0.05 - 0.06	0.19/LOQ		x	Hematopoietic cancer; teratogenic and reproductive effects
n-Butanol	71-36-3	SUMMA TST	13.1 25.4	50 (cXs)		z, y	Eye and mucous membrane irritation; CNS depression
2-Hexanone (MnBK)	591-78-6	SUMMA TST	0.57 - 0.59 0.51	1		x	Irritation; liver, kidney, and nervous system effects
Methylene chloride (A2)	75-09-2	SUMMA TST	<0.02 - 0.061 1.62	LOQ		x	Potential for cancer; tumors of the lung, liver, salivary, and mammary glands in animals
Nitrous oxide	10024-97-2	SUMMA	762		25	x	Reproductive system effects and decreases in audiovisual performance
Dodecane	112-40-3	OVS CCT	36.2 - 46.4 40.3	120		w	Skin and nervous system effects
Tridecane	629-50-5	OVS CCT	40.1 - 63 52	120		w	Skin and nervous system effects
Propane nitrile	107-12-0	SUMMA TST	5.1 - 5.3 5.2	6		x	Hepatic, renal, respiratory, cardiovascular, gastrointestinal, and nervous system effects
Tributyl phosphate	126-73-8	CCT	0.51	0.2		x	Pulmonary irritation; moderate excitation of nervous system in animals

A2 Suspected human carcinogen
(c) Ceiling
(s) Skin designation
(p) Peak concentration
w TRP-derived guideline
x NIOSH REL
y ACGIH TLV
z OSHA PEL
CCT Carbo C Trap

LOQ Limit of quantitation. For carcinogenic materials, NIOSH recommends LOQ as the desired limit.
OVS OSHA versile sampler
STEL Short-term exposure limit
SUMMA A registered trademark of evacuated sampler by Molectrics, Inc., Cleveland, Ohio.
TST Triple-sorbent tube
TWA Time-weighted average

8.0 References

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APPENDIX B.2

SUPPORTING DATA FOR HEADSPACE GASES — LETTER FROM M. B. BIRN TO J. S. DAVIS GIVING CONCENTRATIONS OF HEADSPACE IN TANK 241-C-103

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Battelle
Pacific Northwest Laboratories
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Richland, Washington 99352
Telephone (509)
372-6113

December 2, 1994

Janet Davis
Westinghouse Hanford Company
450 Hills
Richland, WA 99352

The minimum value and the maximum value for each chemical in the attached report represent the lowest and highest concentrations, computed from a single sample taken from the Hanford Waste Tank 241-C-103. The results are sorted by the units in which they are reported. The Chemical ID refers to the Chemical Abstract Services (CAS) number, which uniquely identifies each chemical. The molecular weight is needed to convert from mg/m^3 to ppmv, and the number of reported results is also listed.

The vapor studies are directed and funded by the Waste Tank Safety Program at Westinghouse Hanford Company (WHC). All the samples were taken between May 12 and May 25, 1994, and were analyzed at either the Oregon Graduate Institute of Science and Technology (OGI) or Oak Ridge National Laboratory (ORNL).

Results are reported in the following units:

g/m^3 = grams per cubic meter
mg/m^3 = milligrams per cubic meter
ppbv = parts per billion by volume
ppmv = parts per million by volume

To convert from mg/m^3 to ppmv, use the following formula:

$$mg/m^3 = (ppmv * molecular\ weight)/26.21$$

This formula assumes average tank conditions with temperature equal to 38°C and a pressure of 740 torr.

For detailed information on the sample collection and analysis procedures, refer to the following documents:

Jenkins, R. A., A. B. Dindal, C. E. Higgins, C. Y. Ma, J. T. Skeen, and R. R. Smith. 1994. Analysis of Tank 241-103-C Headspace Components from Sampling Job 7b. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

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Mahon, R. D., C. M. Jones, M. S. Story. 1994. Evaluation of the Capabilities and Use of the Vapor Sampling System for Tank Headspace Sampling and Characterization. WHC-SD-WM-RPT-094, Westinghouse Hanford Company, Richland, Washington.

Rasmussen, R. A., and W. Einfeld. 1994. Hanford Tank 103-C Analyses and Method Validation Development Phase. SAND94-1807, Oregon Graduate Institute of Science and Technology.

Sincerely,

M - B.

Meryl B. Birn
Technical Specialist
Boundary Layer Meteorology Technical Group
EARTH & ENVIRONMENTAL SCIENCES CENTER

MBB:rak

Enclosure

Tank 103-C Concentrations

Chemical Name	Chemical ID	Molecular Weight	Minimum Value	Maximum Value	Number of Results
1,1,2,2-Tetrachloroethane	79-34-5	0.00	0.00 ppbv	0.00 ppbv	6
1,3-Butadiene	106-99-0	54.10	0.00 ppbv	86.00 ppbv	6
1,3-Butadiene, hexachloro	87-68-3	260.74	0.00 ppbv	0.00 ppbv	6
Acetone	67-64-1	58.09	11.10 mg/m3	37.65 mg/m3	10
			5.04 ppmv	12.40 ppmv	4
Acetonitrile	75-05-8	41.06	9.21 mg/m3	21.81 mg/m3	10
			5.91 ppmv	11.03 ppmv	4
Benzene	71-43-2	78.12	-0.39 mg/m3	1.32 mg/m3	10
			47.00 ppbv	86.00 ppbv	6
			0.05 ppmv	0.11 ppmv	4
Benzene, 1,2,4-trichloro	120-82-1	181.44	0.00 ppbv	0.00 ppbv	6
Benzene, 1,2,4-trimethyl-	95-63-6	120.21	0.00 ppbv	0.00 ppbv	6
Benzene, chloro	108-90-7	112.56	0.00 ppbv	0.00 ppbv	6
Benzene, ethyl	100-41-4	106.18	0.00 ppbv	0.00 ppbv	6
Benzene, m-dichloro	541-73-1	147.00	0.00 ppbv	0.00 ppbv	6
Benzene, o-dichloro	95-50-1		0.00 ppbv	0.00 ppbv	6
Benzene, p-dichloro	106-46-7		0.00 ppbv	0.00 ppbv	6
Butanol, n-	71-36-3	74.14	56.70 mg/m3	164.13 mg/m3	10
			20.20 ppmv	34.90 ppmv	4
Butyraldehyde	123-72-8	72.12	1.38 mg/m3	6.91 mg/m3	10

Chemical Name	Chemical ID	Molecular Weight	Minimum Value	Maximum Value	Number of Results
Butyraldehyde	123-72-8	72.12	0.50 ppmv	2.34 ppmv	4
Butyronitrile	109-74-0	69.12	4.19 mg/m3	9.50 mg/m3	10
			1.60 ppmv	3.13 ppmv	4
Carbon monoxide	630-08-0	28.01	0.00 ppmv	29.70 ppmv	31
Carbon tetrachloride	56-23-5	153.81	0.00 ppbv	0.00 ppbv	6
Chloroform	67-66-3	119.37	0.00 ppbv	0.00 ppbv	6
Cis-1,3-dichloropropene	10061-01-5	110.97	0.00 ppbv	0.00 ppbv	6
Decane	124-18-5	142.32	2.20 mg/m3	3.50 mg/m3	11
Dichloroethane, 1,1-	75-34-3	98.96	0.00 ppbv	0.00 ppbv	6
Dodecane	112-40-3	170.30	15.70 mg/m3	296.00 mg/m3	21
			3.41 ppmv	5.22 ppmv	4
Ethane, 1,1,1-trichloro	71-55-6	133.40	0.00 ppbv	0.00 ppbv	6
Ethane, 1,1,2-trichloro	79-00-5		0.00 ppbv	0.00 ppbv	6
Ethane, 1,1,2-trichloro-1,2,2-trifluoro-	76-13-1	187.37	0.00 ppbv	40.00 ppbv	6
Ethane, 1,2-dibromo	106-93-4	187.88	0.00 ppbv	0.00 ppbv	6
Ethane, 1,2-dichloro	107-06-2	98.96	0.00 ppbv	0.00 ppbv	6
Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro	76-14-2	170.92	0.00 ppbv	0.00 ppbv	6
Ethyl chloride	75-00-3	64.52	0.00 ppbv	0.00 ppbv	6
Ethylene, 1,2-dichloro-	156-59-2	96.94	0.00 ppbv	0.00 ppbv	6
Ethylene, tetrachloro	127-18-4	165.82	0.00 ppbv	0.00 ppbv	6

Chemical Name	Chemical ID	Molecular Weight	Minimum Value	Maximum Value	Number of Results
Ethylene, trichloro	79-01-6	131.38	0.00 ppbv	0.00 ppbv	6
Heptane	142-82-5	100.23	1.00 mg/m3	3.58 mg/m3	10
			0.45 ppmv	0.76 ppmv	4
Heptanenitrile	629-08-3	111.18	2.14 mg/m3	3.51 mg/m3	10
			0.55 ppmv	0.64 ppmv	4
Heptanone, 2-	110-43-0	114.21	1.51 mg/m3	2.91 mg/m3	10
			0.47 ppmv	0.67 ppmv	4
Hexane	110-54-3	86.20	2.37 mg/m3	5.13 mg/m3	10
			0.73 ppmv	0.85 ppmv	4
Hexanenitrile	628-73-9	97.18	2.51 mg/m3	4.37 mg/m3	10
			0.68 ppmv	0.89 ppmv	4
Hexanone, 2-	591-78-6	100.18	1.00 mg/m3	2.60 mg/m3	10
			0.39 ppmv	0.64 ppmv	4
Hydrogen	1333-74-0	2.02	0.00 ppmv	894.00 ppmv	31
Mesitylene	108-67-8	120.21	0.00 ppbv	0.00 ppbv	6
Methane, dichlorodifluoro	75-71-8	120.91	0.00 ppbv	0.00 ppbv	6
Methane, trichlorofluoro	75-69-4	137.36	81.00 ppbv	112.00 ppbv	6
Methyl bromide	74-83-9	94.95	0.00 ppbv	0.00 ppbv	6
Methyl chloride	74-87-3	50.49	0.00 ppbv	0.00 ppbv	6
Methylene chloride	75-09-2	84.93	-0.01 mg/m3	21.76 mg/m3	10
			39.00 ppbv	121.00 ppbv	6

Chemical Name	Chemical ID	Molecular Weight	Minimum Value	Maximum Value	Number of Results
Methylene chloride	75-09-2	84.93	0.32 ppmv	3.08 ppmv	4
Nitrous oxide	10024-97-2	44.02	681.00 ppmv	836.00 ppmv	31
Nonane	111-84-2	128.29	0.39 mg/m3	1.90 mg/m3	10
			0.20 ppmv	0.39 ppmv	4
Nonanenitrile	2243-27-8	139.27	-0.57 mg/m3	0.09 mg/m3	10
			0.12 ppmv	0.17 ppmv	4
o-Xylene	95-47-6	106.16	0.00 ppbv	0.00 ppbv	6
Octane	111-65-9	114.26	0.60 mg/m3	2.90 mg/m3	10
			0.24 ppmv	0.44 ppmv	4
Octanenitrile	124-12-9	125.24	0.23 mg/m3	2.10 mg/m3	10
			0.24 ppmv	0.44 ppmv	4
Octanone, 2-	111-13-7	128.24	0.28 mg/m3	1.58 mg/m3	10
			0.21 ppmv	0.29 ppmv	4
p-Xylene	106-42-3	106.18	0.00 ppbv	0.00 ppbv	6
Pentanone, 2-	107-87-9	86.15	0.55 mg/m3	5.20 mg/m3	10
			0.17 ppmv	1.59 ppmv	4
Phosphonic acid, butyl-, dibutyl ester	78-46-6	250.36	-1.93 mg/m3	0.72 mg/m3	11
Propane, 1,2-dichloro	78-87-5	112.99	0.00 ppbv	0.00 ppbv	6
Propene, 3-chloro	107-05-1	76.53	0.00 ppbv	0.00 ppbv	6
Propionitrile	107-12-0	55.09	6.19 mg/m3	10.47 mg/m3	10
			2.96 ppmv	3.63 ppmv	4

Chemical Name	Chemical ID	Molecular Weight	Minimum Value	Maximum Value	Number of Results
Styrene	100-42-5	104.16	0.00 ppbv	0.00 ppbv	6
Tetradecane	629-59-4	198.44	64.00 mg/m3	88.00 mg/m3	11
Toluene	108-88-3	92.15	-11.97 mg/m3	7.30 mg/m3	10
			15.00 ppbv	25.00 ppbv	6
			0.02 ppmv	0.05 ppmv	4
Toluene, ar-chloro	25168-05-2	126.59	0.00 ppbv	0.00 ppbv	6
Toluene, p-Ethyl-	622-96-8	120.21	0.00 ppbv	0.00 ppbv	6
Total non-methane hydrocarbons	*TNMHC	0.00	0.45 g/m3	0.65 g/m3	5
			0.49 mg/m3	0.49 mg/m3	1
Trans-1,3-dichloropropene	10061-02-6	110.97	0.00 ppbv	0.00 ppbv	6
Tributyl phosphate	126-73-8	266.36	4.40 mg/m3	11.60 mg/m3	11
Tridecane	629-50-5	184.41	15.27 mg/m3	388.00 mg/m3	21
			3.19 ppmv	5.66 ppmv	4
Undecane	1120-21-4	156.35	18.00 mg/m3	32.00 mg/m3	11
Valeronitrile	110-59-8	83.15	2.65 mg/m3	5.92 mg/m3	10
			0.84 ppmv	1.19 ppmv	4
Vinyl chloride	75-01-4	62.50	0.00 ppbv	0.00 ppbv	6
Vinylidene chloride	75-35-4	96.94	0.00 mg/m3	0.00 mg/m3	10
			0.00 ppbv	0.00 ppbv	6
			0.00 ppmv	0.00 ppmv	4
Xylene, m-	108-38-3	106.16	0.00 ppbv	0.00 ppbv	6

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APPENDIX C.0

WAIVER TO WHC-CM-4-46 TO ALLOW USE OF REVISED TOXIC CHEMICAL GUIDELINES