HmLm0131 101950/BB2c

2. ECN Category (mark one)		3. Originator's Name, Organization, MSIN, and Telephone No.		4. USQ Required?	5. Date
Supplemental	○	T. B. McCall, 423, B4-47, 372-2835		○ Yes ◉ No	10/14/99
Direct Revision	◉				
Change ECN	○	6. Project Title/No./Work Order No.	7. Bldg./Sys./Fac. No.		8. Approval Designator
Temporary	○	TWRS			
Standby	○		Tank Farms		N/A
Supersedure	○	9. Document Numbers Changed by this ECN (includes sheet no. and rev.)	10. Related ECN No(s).		11. Related PO No.
Cancel/Void	○	TWR-3738, Rev. 0	N/A		N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Completed	12d. Restored to Original Condition (Temp. or Standby ECNs only)
○ Yes (fill out Blk. 12b)	N/A	N/A	N/A
◉ No (NA Blks. 12b, 12c, 12d)		Design Authority/Cog. Engineer Signature & Date	Design Authority/Cog. Engineer Signature & Date

13a. Description of Change   13b. Design Baseline Document? ○ Yes ◉ No

This revision replaces TWR-3738, Rev 0 except for Appendix C, "Consequence Calculations for Hypothetical 27,000-gallon Spill," which was incorporated by ECN 605730 on 2/9/1999. Revision 1 incorporates changes in all sections of TWR-3738, Rev. 0 and provides several new sections covering postulated leaks in Cleanout Boxes and in pits. Rev. 1 provides calculation notes to document the author's analysis, but are not to be used as the final or sole document to authorize activities or justify facility modifications.

14a. Justification (mark one)		14b. Justification Details
Criteria Change	○	Supplemental analyses were requested to determine the limiting lengths of transfer piping connected to COBs provided with supplemental covers or the limiting volumes of pits for which the consequences are within the current Authorization Basis and Risk Evaluation Guidelines.
Design Improvement	◉	
Environmental	○	
Facility Deactivation	○	
As-Found	○	
Facilitate Const.	○	
Const. Error/Omission	○	
Design Error/Omission	○	

15. Distribution (include name, MSIN, and no. of copies)
See distribution list.

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ID: 21

A-7900-013-2 (10/97)

A-7900-013-1

16. Design Verification Required	17. Cost Impact		18. Schedule Impact (days)

16. Design Verification Required

○ Yes

◉ No

17. Cost Impact

ENGINEERING

Additional ○ $ _____

Savings ○ $ _____

CONSTRUCTION

Additional ○ $ _____

Savings ○ $ _____

18. Schedule Impact (days)

Improvement ○ _____

Delay ○ _____

19. 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 13. Enter the affected document number in Block 20.

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 ☐	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 ☐	_____ ☐

20. 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
N/A		

21. Approvals

	Signature	Date		Signature	Date
Design Authority	N/A		Design Agent		
Cog. Eng.	T. B. McCall B4-47	11/30/99 10/14/1999	PE		
Cog. Mgr.	B. E. Hey B4-47	10/10/99	QA		
QA	N/A		Safety		
Safety	N/A		Design		
Environ.	N/A		Environ.		
Other			Other		
G. L. Jones	R1-44	10/10/99			
Peer Review J.C. Van Keuren		11/30/99			

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

DISTRIBUTION SHEET

To	From			
DE&SH	FDNW SA & Nuclear Engineering	Page 1 of 1		

Date 10/14/99

EDT No. N/A

ECN No. 638727

Project Title/Work Order

Mitigated Transfer Line Leaks that Result in Surface Pools and Spray Leaks into Pits

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
G. W. Gault	R1-44	X			
B. E. Hey	B4-47	X			
G. L. Jones	R1-44	X			
S. N. Maruvada	A3-02	X			
T. B. McCall	B4-47	X			
G. W. Ryan	A3-07	X			
Central Files (2)	B1-07	X			
TWRS Docket Files (2)	R1-44	X			
TWRS S&L Files (3)	R1-44	X			
TWRS DMC	R1-29	X			
Central Files	B1-07	X KN			
DOE/RL Reading Room	H2-53	X			

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Mitigated Transfer Line Leaks that Result in Surface Pools and Spray Leaks into Pits

B. E. Hey and T. B. McCall
Fluor Federal Services, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 638727 UC:
Org Code: 403 Charge Code: 101950BB20 HMLMC131
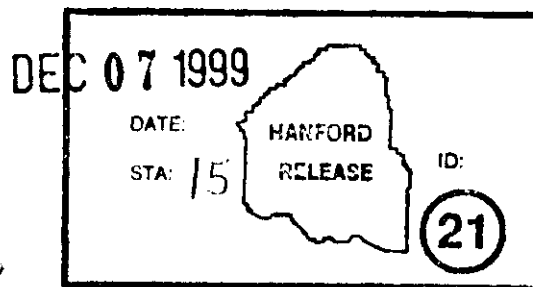B&R Code: Total Pages: ~~117~~ 121 KN

Key Words: Clean-out box, leak, spill, waste transfer

Abstract: This analysis provides radiological and toxicological consequence calculations for postulated mitigated leaks during transfers of six waste compositions. Leaks in Cleanout Boxes equipped with supplemental covers and leaks in pits are analyzed. The limiting lengths of transfer piping connected to COBs with supplemental covers or the limiting volumes of pits are found for which the consequences are within the current Authorization Basis or Risk Evaluation Guidelines.

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DEC 07 1999

DATE:
STA: 15 HANFORD RELEASE ID:
(21)

Karen M. Noland 12/7/99
Release Approval Date Release Stamp

Approved For Public Release

RECORD OF REVISION

(2) Title

Mitigated Transfer Line Leaks that Result in Surface Pools and Spray Leaks into Pits

		Change Control Record		
			Authorized for Release	
(3) Revision	**(4) Description of Change - Replace, Add, and Delete Pages**		**(5) Cog. Engr.**	**(6) Cog. Mgr. Date**
0	**(7)** Initial document release via EDT #622324		B. E. Hey	D. S. Leach
0A	Add Appendix C (ECN 605730)		D. A. Himes 2/9/99	B. E. Hey 2/9/99
1 RS	Replace entire document (ECN 638727)		T. B. McCall	B. E. Hey 12/1/99

MITIGATED TRANSFER LINE LEAKS THAT RESULT IN SURFACE POOLS AND SPRAY LEAKS INTO PITS

Prepared by:

B. E. Hey, T. B. McCall
Fluor Federal Services, Inc.

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List of Terms

AB	Authorization Basis
ARF	Airborne Release Fraction
AW	Aging Waste
COB	Cleanout Box
DST	Double Shell Tanks
EDE	Effective Dose Equivalent
LPF	Leak Path Factor
MAR	Material at Risk
MEI	Maximum Exposed Individual
RRF	Respirable Release Fraction
RPP	River Protection Project
Sv	Sievert (unit of radiation dose)
SOF	Sum of Fractions
SSC	Structures, Systems, and Components
SST	Single Shell Tanks
TWRS	Tank Waste Remediation System
TSR	Technical Safety Requirement
ULD	Unit Liter Dose
WFD	Waste Feed Delivery
χ/Q	Atmospheric Dispersion Coefficient ("Chi over Q")

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Mitigated Transfer Line Leaks that Result in Surface Pools and Spray Leaks Into Pits

1.0 INTRODUCTION AND PURPOSE

This report documents the estimated mitigated consequences of waste transfer leaks inside a clean out box (COB) or other confining structure (e.g. a valve pit). The COB is fitted with a supplemental enclosure and the pit is analyzed with cover blocks in place. The postulated 20 gpm leak is assumed to be detected by the alarm system in the COB but, due to the small volume of the COB (approximately 50 gallons or 0.2 m^3) it quickly overflows and a surface pool forms. Even after the transfer pump is shut off, there is a potentially large volume of waste material that could drain or siphon back through a connected waste slurry transfer pipe. The analyses of leaks inside a pit use the pit volume as an input parameter.

USQD TF-97-0923 Rev. 1 determined that a USQ existed in the TWRS BIO Rev. 0 because its evaluation of potential waste transfer leaks did not conservatively bound leaks in structures having a volume of less than 15 m^3 which could overflow. JCO, *Justification for Continued Operation of Transfer Lines Having Structures with Less Volume Than the 241-A-A Valve Pit*, HNF-2296 (HNF1998b) was written to document the consequences of a leak within a COB and to require supplemental covers for structures having a volume less than 15 m^3. *Mitigated Transfer Line Leaks that Result in Surface Pool*, TWR-3738, Rev. 0, (Hey 1999) was written to address the potential for a greater drain back volume (i.e., length of connecting piping involved in the waste transfer) than was considered in HNF-2296. Transfer line structures less than 15 m^3 volume but without supplemental covers have been identified. The purpose of the analysis of leaks in pits in this document is to determine the maximum size pit such that the consequences of a leak are within the current Authorization Basis.

This report is an extension of the analyses reported in *Mitigated Transfer Line Leaks that Result in Surface Pool*, TWR-3738, Rev. 0, (Hey 1999b). That report analyzed four kinds of waste for a postulated 20 gpm leak at a Cleanout Box with a Supplemental Cover that prevented waste sprays directly into the atmosphere. ECN 605730 to Hey 1999b provided *Appendix C, Consequence Calculations for Hypothetical 27,000-gallon Spill*. Appendix C of TWR-3738, Rev. 0A is not included here because its methodology has been revised. However, Appendix C of TWR-3738, Rev. 0A is still applicable to the 242-A Evaporator.

The purpose of this analysis is to determine the conditions for which the radiological and toxicological consequences of a leak will be equal to or less than a set of specific limits. The first set of limits is the Radiological Risk Evaluation Guidelines (REGs) provided in *Tank Waste Remediation System Final Safety Analysis Report*, HNF-SD-WM-SAR-067, Revision 1, Table 3.4.1-1 (HNF-1999). A second set of limits is in the current Authorization Basis (AB) for the River Protection Project (RRP). These limits are applied to leaks resulting in surface pools and are reported in *Calculation Notes for Surface Leak Resulting in Pool, TWRS FSAR Accident Analysis*, WHC-SD-WM-CN-049, Rev. 0-B (Jones 1998). A third set of limits is also part of the current AB and applies only to spray leaks of AWF waste in valve pits or from overground waste

transfer lines. The third set is provided in Table HNF-SD-WM-BIO-001 REV 1 of *FSAR Transition Spray Leak Analysis, Rev. 0*, HNF-5147 (Ryan 1999).

In the first set of cases for leaks postulated inside a Cleanout Box, the results define the longest length of transfer pipe that could drain back to the COB and not exceed the consequences in Jones 1998. A second set of cases was run to define the longest length of transfer pipe that could drain back to the COB and not exceed the Radiological Risk Evaluation Guidelines. In the cases for leaks inside pits with cover blocks, the results define the largest pit volume that would not exceed the consequences in Ryan 1999. A second set of pit leak cases was run to define the largest pit volume that would not exceed the Radiological Risk Evaluation Guidelines.

This analysis considers the following liquid/solids content (%) and waste compositions:

67/33 AWF	67/33 DST	67/33 SST
95/5 AWF	95/5 DST	95/5 SST

Jones (1998) also evaluated this scenario for the 67/33 AWF waste, but with a shorter pipe length, hence smaller potential drain back volume. The Jones (1998) results are part of the authorization basis (AB) for waste transfers (HNF 1998b). The Radiological Risk Evaluation Guidelines (REGs), the Safety Basis in Jones (1998), and the Safety Basis in Ryan (1999) are shown below.

Table 1-1. Criteria for Accident Analysis

Receptor Location	Risk Evaluation Guideline	Jones 1998	Ryan 1999
Onsite Radiological	5.0E-03 Sv	5.1E-03 Sv	4.1E-2 Sv
Offsite Radiological	1.0E-03 Sv	6.6E-06 Sv	3.7E-5 Sv
Onsite Toxicological	1.0E+00	1.4E-01	8.1E-2
Offsite Toxicological	1.0E+00	7.5E-04	4.2E-4

To show that the net consequences of a larger leak in a COB are no greater than that previously analyzed in Jones (1998) or in the REGs, justifiable yet different assumptions are made with respect to release mechanisms. The most important of these is that the splash and splatter release mechanism as previously assumed can be mitigated by a Supplemental Cover that is placed over the COB. The splash and splatter release mechanism is also effectively mitigated by the pit cover blocks. Another refinement is that the atmospheric dispersion of aerosols released from the Supplemental Cover is analyzed separately from the atmospheric dispersion of aerosols due to entrainment from the pool surface due to wind. Previously, the atmospheric dispersion coefficients used for entrainment was based on a 1 m/s wind speed whereas the entrainment rate was based on a 5 m/s wind speed. In addition, the dependence of the aerosol entrainment on pool diameter is taken into account. Previously, a pool diameter of 200 m was assumed.

With these revised methods, this analysis determines for each waste composition the length of transfer line that could completely drain through the COB within 24 hours onto the

ground yet have consequences within the Authorization Basis or the REGs. The pit analysis determines for each waste composition the maximum pit volume that could release all its aerosol into the environment within one hour of leak initiation.

For the pit analyses, the pit cover blocks are effective in mitigating sprays, splash, and splatter in the confined volume such that there is no direct release into the environment. Instead, the aerosols generated from the aforementioned processes are assumed to be released from the pit at the quasi-equilibrium concentration of 0.1 gram per cubic meter. The aerosol is assumed to be released in one hour, so workers are exposed to the entire release.

It is important to note that currently two kinds of evaluations are used to provide a bounding analysis of mitigated waste transfer leak scenarios. One is an analysis which maximizes the unconfined spill so that the extent of gamma-ray exposure and entrainment due to wind across the pool can be assessed. The other is an analysis which maximizes the confinement volume (e.g. a valve pit) so that the extent of greater aerosol leakage can be assessed. The former analysis identifies the limiting leak quantity and associated controls while the latter analysis identifies the limiting confinement and associated controls. The COB analyses in this document addresses the situation where confinement or Supplemental Cover volume is minimal and the extent of the surface pool is maximized. The pit analyses in this document address leaks into pits. The reports *Calculation Notes for Surface Leak Resulting in Pool, TWRS FSAR Accident Analysis*, WHC-SD-WM-CN-049, Rev. 0 (Hall 1996a), Hall 1996b, Hall 1996c and *Revised Spray Leak Calculations for Project W-058*, HNF-2542, Rev. 0 (Van Keuren 1998) address large pits (e.g. 75 m^3) for various waste compositions.

Application of this analysis to other leak scenarios requires judicious treatment. In order to avoid a misapplication, one should carefully understand the means of mitigation discussed in Section 2.0, the representative accidents discussed in Section 3.0, the limiting leak quantities into COBs (both 1 hr and 24 hr) identified in Section 5.0, and the limiting pit volumes for 1 hr and 24 hours identified in Section 5.0. As long as the scenario in question meets those conditions, the consequences reported here will be bounding.

The first accident represented here is a 20 gpm waste transfer leak occurring within a small (50 gallon or about 7 ft^3) enclosure (viz. Cleanout Box). The COB has a Supplemental Cover, a 1.2 m^3 enclosure. Leak detection is accomplished by an engineered safety feature. The leak alarm is assumed to occur essentially instantaneously. Evacuation of affected personnel is assumed to be completed one hour after leak initiation. The leak rate due to drainage of connected piping is conservatively assumed to be the same as the pumped leak rate (20 gpm). Abatement measures are taken to prevent dry entrainment from the exposed surface of the spill.

The second accident represented here is a transfer leak occurring within a large confinement such as a valve pit. The pit has cover blocks in place. The entire pit volume is assumed to be displaced within a short time frame (i.e., 1 hr) into the environment at an aerosol concentration of 0.1 g/m^3. It is assumed that the pit confines the entire leak such that there is no surface pool.

2.0 MEANS OF MITIGATION

This analysis provides conservative dose estimates for leaks during waste transfer operations with mitigation controls. The mitigation credited in this analysis include engineered barriers and administrative controls. Transfer operations without this mitigation may not be bounded by these results. These controls are:

- With the exception of wind induced entrainment from soil, all sources of aerosol generation (e.g., liquid spray, splatter and splashing) are confined (see Limiting Control for Operation 3.1.1, Administrative Control 5.22 in *Tank Waste Remediation System Technical Safety Requirements*, HNF-SD-WM-TSR-006 [HNF 1998a], and *Justification for Continued Operation of Transfer Lines Having Structures with Less Volume Than the 241-A-A Valve Pit*, HNF-2296 [HNF 1998b]). The confinement system attributes specifically credited are as follows:
  - The outer confinement naturally "breathes" in order to equalize internal pressure with the environment but openings are limited to prevent the free flow of wind through the confinement.
  - The confinement can fill up with liquids and overflow but it does not release liquids at any significant pressure.
  - The geometry is such that a release of liquid waste does not result in an unconfined free-fall of liquids by more than a few inches.

- Preventative configuration controls prevent high volume leaks (i.e., >20 gpm) (see Administrative Control 5.12 in HNF 1998a).

- Leak detection is credited for initiating transfer pump shutdown and evacuation of onsite personnel (see Limiting Control for Operation 3.1.3 in HNF 1998a).

- Evacuation of onsite personnel within one hour of surface spill formation is credited to limit their exposure to radiation fields and aerosol entrained from surface waste spills (see Administrative Control 5.14 in HNF 1998a).

- Dry entrainment is prevented by emergency response procedures for leakage containment and removal (see Administrative Control 5.14 in HNF 1998a).

- Transfer pump shutdown is credited for limiting the total surface waste spill volume, including drainback, to acceptable public exposure levels (see Limiting Control for Operation 3.1.3 in HNF 1998a).

3.0 ACCIDENT ANALYSIS METHODOLOGY

This analysis applies accident analysis methods similar to that used in the analyses of leaks and sprays in HNF 1999, *Tank Waste Remediation System Final Safety Analysis Report*, and supporting Calculation Notes. The general approach used for these kinds of analyses are summarized in the following sections. Section 4.0 presents the details of analysis methodology that is specific to the cases analyzed herein.

3.1 RADIOLOGICAL HAZARD

The total onsite dose can include inhalation and gamma rays from shine and skyshine. The total offsite dose is the sum of inhalation and ingestion pathways. Usually the dominant exposure pathway is inhalation. For the inhalation and ingestion pathways WHC-SD-WM-SARR-016 (Van Keuren 1996a) describes the individual dose as:

$$\text{Inhalation:} \quad D_{inh} = Q \times \chi/Q \times R \times OF \times ULD_{inh} \quad \text{(Eq. 1)}$$

$$\text{Ingestion:} \quad D_{ing} = Q \times \chi/Q \times ULD_{ing} \quad \text{(Eq. 2)}$$

where:

D_{inh} = dose due to inhalation (Sv)
D_{ing} = dose due to ingestion (Sv)
Q = source term (L),
χ/Q = atmospheric diffusion coefficient (s/m^3),
R = breathing rate (3.3E-04 m^3/sec for 12-hour exposure, 2.7E-04 m^3/sec for 24-hour) (WHC-SD-WM-SARR-016 [Van Keuren 1996a], the higher breathing rate is used herein for leaks in cleanout boxes).
OF = onsite occupancy factor (1.0 for the analyses herein) (WHC-SD-WM-SARR-016 [Van Keuren 1996a]),
ULD_{inh} = inhalation unit liter dose (Sv/L),
ULD_{ing} = ingestion (Sv-m^3/s-L).

The source term, Q, is the amount of radioactive material released to the environment. *The initial source term is the amount of radioactive material driven airborne at the accident source.* The initial respirable source term, a subset of the initial source term, is the amount of radioactive material driven airborne at the accident source that can be inhaled. Lesser source terms are determined by applying filtration or deposition factors to the initial source term.

For the analyses herein, the methodology accounts for the fact that different atmospheric conditions are conservative for the two release mechanisms, wind-driven release from the Supplemental Cover and wind-driven wet entrainment from the waste pool. The equations below are used to incorporate these two effects.

$$D_{inh} = [(Q \times \chi/Q)_{sc} + (Q \times \chi/Q)_{wr}] \times R \times ULD_{inh} \quad \text{(Eq. 3)}$$

$$D_{ing} = [(Q \times \chi/Q)_{sc} + (Q \times \chi/Q)_{wr}] \times ULD_{inh} \quad (Eq. 4)$$

where:

subscript sc denotes the Q and χ/Q product for release from the Supplemental Cover
subscript wr denotes the Q and χ/Q product for release due to wet-entrainment from the pool.

In the cases for leaks within a pit and no surface pool, equations one and two above apply and the χ/Q values are for low wind speeds (i.e. the same as used for $[\chi/Q]_{sc}$).

The airborne source term is typically estimated by the following five-component linear equation:

$$Q = MAR \times DR \times ARF \times RF \times LPF \quad (Eq. 5)$$

where:

Q = Airborne Source Term,
MAR = Material-at-Risk,
DR = Damage Ratio,
ARF = Airborne Release Fraction,
RF = Respirable Fraction, and
LPF = Leak Path Factor.

The initial source term and initial respirable source term are products of the first three factors and first four factors, respectively. A depleted source term after a subsequent stage of deposition or filtration is a product of the initial source term multiplied by the leak path factor of the specific stage.

3.2 MATERIAL-AT-RISK (MAR)

The material-at-risk is the amount of radionuclides available to be acted on by a given physical stress. For tank farm facilities, the MAR is taken to be the maximum quantity of radionuclide present or reasonably anticipated in each location. In the analyses herein for leaks inside COBs, there are two materials-at-risk. These are the quantity of waste leaked onto the soil and the quantity of waste released from the Supplemental Cover.

3.3 DAMAGE RATIO (DR)

The damage ratio is the fraction of the MAR actually impacted by the accident-generated conditions. The DR is estimated based upon engineering analysis of the response of structural materials and materials-of-construction for containment to the type and level of stress/force

generated by the event. Standard engineering approximations are typically used. These approximations often include a degree of conservatism due to simplification of phenomena to obtain a useable model, but the purpose of the approximation is to obtain, to the degree possible, a realistic understanding of potential effects. For the analyses herein, the DR is unity.

3.4 AIRBORNE RELEASE FRACTION (ARF)

The ARF is the coefficient used to estimate the amount of a radioactive material suspended in air as an aerosol and available for transport due to a physical stress from a specific accident. For discrete events, the ARF is a fraction of the material affected.

The ARFs used in the following analyses are taken from DOE (1994) which are based primarily upon experimentally measured values for the specific material (e.g., plutonium, uranium, mixed fission products) or surrogates subjected to the particular type of stress under controlled conditions. Attention is given to the parameters, if known, that may have a significant influence upon suspension by the specific mechanism and the uncertainty in the measurement as indicated by the variability of the results.

It is important to note that the experiments discussed in DOE (1994) evaluate release phenomena holistically. No attempt is made to precisely characterize total airborne material in terms of individual mechanisms acting within an overall given release.

3.5 RESPIRABLE FRACTION (RF)

The RF is the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system and is commonly assumed to include particles 10-μm Aerodynamic Equivalent Diameter (AED) and less. The principal emphasis in this document is directed toward the potential downwind hazard to the populations at some distance from the point of source term generation. The product of the ARF and RF are frequently presented as RRF, the respirable release fraction. For the analyses herein, the RRF values will be used.

3.6 LEAK PATH FACTOR (LPF)

The LPF is the fraction of the radionuclides in the aerosol transported through some confinement deposition or filtration mechanism. The LPF is a calculated or standard value based upon (1) established relationships between size of the particulate material, airborne transport mechanisms, and losses by depositions mechanisms, or (2) specified filtration efficiencies. For the analyses herein, the LPF is unity for waste leaked to form a pool on the soil. The derivation for an LPF for aerosols generated by splash, splatter, and spray inside the Supplemental Cover is described in sections 4.3.1 and 4.3.2. Based on the sections above, the source term, Q, for the analyses herein becomes the following:

$$Q = MAR \times RRF \times LPF \qquad (Eq.\ 6)$$

3.7 TOXICOLOGICAL ANALYSIS

The methodology that is used to calculate the toxicological exposure consequences is documented in WHC-SD-WM-SARR-011 (Van Keuren 1996b). In this method, the released quantity (or release rate) is multiplied by the appropriate sum-of-fraction multiplier, M_{SOF}, from Table 3-8 of WHC-SD-WM-SARR-011 (Van Keuren 1996b). M_{SOF} values are dependent on the type of release (puff-type or continuous), the waste material released, and the event frequency. The following equation is used for the analyses herein:

$$SOF = Q' \times M_{SOF} \qquad (Eq.\ 7)$$

where:

SOF = denotes the sum of toxicological exposure fractions for each toxic chemical as compared to its exposure criteria,
Q' = quantity released in units of L/s,
M_{SOF} = sum-of-fraction multiplier in units of L^{-1} or s/L.

Toxicological consequences can also be estimated using an airborne release rate using the equation:

$$SOF = Q * ARR * M_{SOF} \qquad (Eq.\ 8)$$

where:

Q = respirable source term (L)
ARR = airborne release rate (1/s)
M_{SOF} = sum-of-fraction multiplier (s/L)

3.8 EXPOSURE DURATIONS

For unmitigated events, onsite individuals are assumed to be exposed to accidental releases for 12 hours. The basis for this is that a crew may be required to work an extended shift which may be as long as 12 hours. Offsite individuals are assumed to be exposed to accidental releases for 24 hours. Offsite consequences consider ingestion for 24 hours after the release as well as inhalation. Mitigated exposure durations depend upon the timing of the control used (e.g., accident detection, evacuation). For the mitigated accidents analyzed herein, the onsite individual is assumed to be exposed for one hour. This is conservatively based on the time required to acknowledge the leak alarm (30 min.) plus the time required to evacuate the affected area.

3.9   RISK EVALUATION GUIDELINES

For "Anticipated" events, the risk guidelines are 5 mSv onsite and 1 mSv offsite. Toxic chemical risk guidelines require the SOF consequences to be less than 1.

3.10 ATMOSPHERIC DISPERSION

The Gaussian straight-line continuous plume model is employed for calculating atmospheric diffusion. The method assumes a ground level release and the concentration is calculated at the lateral centerline of the plume. Normally for safety analysis purposes, the χ/Q is chosen to represent "near" worst case conditions of wind speed, direction, atmospheric stability, and receptor location. "Near" worst case is usually defined as the combination which is bounding 95% of the time for all sectors or 99.5% of the time in any given sector. Since the χ/Q' is inversely proportional to wind speed, a low wind speed condition is worse.

Specific values are used to calculate the dose component for release from the Supplemental Cover represented as $(Q \times \chi/Q)_{sc}$ in Equation 3. The χ/Q_{sc} values assume 1.1 m/s wind speed and Class F conditions taken from Van Keuren (1996a) and shown in Table 3-1.

For an extended release duration (e.g., 24-hour release), Van Keuren (1996a) recommends use of a logarithmic interpolation between the plume meander χ/Q and the chronic annual average χ/Q for the onsite and offsite radiological calculations. For a desired time t, the logarithmic interpolation method for $\chi/Q(t)$ for the offsite receptor is given by:

$$\chi/Q_{off} = 10^y \quad \text{(Eqn. 9A)}$$

where $y = y(t) = a - [b/c] \times [\log(2) - \log(t)]$ and
$a = \log(2.12E\text{-}05)$
$b = \log(2.12E\text{-}05) - \log(1.24E\text{-}07)$
$c = \log(2\ hr) - \log(8760\ hr)$
$t = $ extended release time (hours).

The logarithmic interpolation for $\chi/Q(t)$ for the onsite receptor is given by:

$$\chi/Q_{on} = 10^y \quad \text{(Eqn. 9B)}$$

where y and c are the same as above, but
$a = \log(1.13E\text{-}02)$
$b = \log(1.13E\text{-}02) - \log(4.03E\text{-}4)$

The table below provides atmospheric dispersion coefficients for various durations.

Table 3-1. Atmospheric Dispersion Coefficients (χ/Q).

Receptor (duration)	Integrated χ/Q' (s/m^3)
Onsite (1 hr)	3.41 E-02
Onsite (2 hr)[a]	1.13 E-02
Onsite (12 hr)	5.54 E-03
Onsite (8760 hr, chronic annual)	4.03 E-04
Offsite (1 hr)	2.83 E-05
Offsite (2 hr)[a]	2.12 E-05
Offsite (4 hr)	1.39 E-06
Offsite (12 hr)	7.07 E-06
Offsite (24 hr)	4.62 E-06
Offsite (8760 hr, chronic annual)	1.24 E-07

[a]Value used to interpolate for other dispersion coefficients.

Specific values are used to calculate the dose component for release from the pool by air entrainment (wet entrainment) which is represented as $(Q \times \chi/Q)_{wr}$ in Equation 3. For the mass release rates for wet (and dry) entrainment a high wind speed condition is worse. Thus, choosing a low wind speed χ/Q and a high wind speed MRR would provide an unrealistic estimate of potential consequences. The "near" worst case condition is taken to be the combination of atmospheric diffusion coefficient and mass release rate such that airborne concentrations downwind are bounding 95% of the time when the wind is in that direction. The method for obtaining χ/Qs for wet entrainment is described in *Refined Consequence Analysis of Subsurface Leak from TWRS Facilities that Result in a Surface Pool*, TWR-3958 (Hey 1999a).

The combination of conditions most closely representing the 95% bounding (or greater) case is given in Table 3-2 below. These values represent point source acute releases at ground level. The χ/Q_{wr} values assume 9.8 m/s wind speed and Class D conditions. For simplicity no credit is taken for plume meander or the distributed area of the source. The χ/Q_{wr} values are used in Equation 3 to calculate the dose component for release from wet entrainment from the pool represented as $(Q \times \chi/Q)_{wr}$.

Table 3-2. 95% Atmospheric Diffusion Coefficients for Use in Conservative Estimates of Acute Exposure Due to Wind Entrainment (from Hey 1999)

Receptor Description	χ/Q' (s/m^3)	Stability Class and Wind Speed
On-Site (100 m any direction)	7.57E-4	D @ 9.8 m/s
Off-Site (8,760 m north to near river bank)	4.92E-7	D @ 9.8 m/s

3.11 UNIT LITER DOSES AND ACTIVITIES

The RPP transfer pumps can potentially pump any waste within the RPP with a maximum solid content of 33 percent (liquid content 67%). The analyses herein assume two values of solids concentrations, 33% and 5%, for the three types of waste, AWF, DST, and SST. The ULD values are taken from Van Keuren (1996a). Each of the waste types contain several radionuclides that contribute to the ULDs. The Cs-137 concentration provides an effective indicator of the relative gamma emissions for the purpose of shine and skyshine analysis.

$$\text{Gamma} = V / V_{ref} \times Cs / Cs_{ref} \times 65.9 \text{ mr/hr} \times C \qquad \text{(Eqn. 10)}$$

where:

C	conversion from mr (milli-rem) to Sv (Sievert)
V	volume of pool (gal)
V_{ref}	volume of reference pool (1200 gal)
Cs	Cs-137 activity in specified waste (Bq/L)
Cs_{ref}	Cs-137 activity in reference waste (Bq/L)

The ULDs and Cs-137 concentrations for the six wastes analyzed herein are shown in the table below.

Table 3-3. TWRS Waste Composite Unit Liter Doses and
Activity Concentrations (from Hey 1999a)

Waste Composition (percent liquids/solids)	Inhalation ULD (Sv/L)	24hr Ingestion ULD (Sv-m³/s-L)	Cs-137 Concentration (Bq/L)
AWF 67/33	5.6E+5	2.7E+0	9.13E+10
AWF 95/5	8.6E+4	4.9E-1	8.85E+10
DST 67/33	1.8E+5	2.0E-1	5.90E+10
DST 95/5	3.2E+4	8.9E-2	5.90E+10
SST 67/33	8.0E+4	1.4E+0	4.77E+10
SST 95/5	2.1E+4	2.5E-1	2.59E+10

3.12 SUM OF FRACTIONS MULTIPLIER

The SOF multipliers depend upon the accident frequency selection. For most accidents the frequency is identified to be "Anticipated." The SOF multipliers for the wastes analyzed herein are calculated from data taken from Van Keuren (1996b) and shown below.

Table 3-4. Anticipated-Frequency Continuous-Release SOF Multipliers (s/L)

Waste Form	Onsite	Offsite
AWF 67/33	1.26E4	6.83E1
AWF 95/5	1.04E4	1.75E1
DST 67/33	1.26E4	6.83E1
DST 95/5	1.04E4	1.75E1
SST 67/33	1.96E4	3.64E1
SST 95/5	1.11E4	1.23E1

4.0 SOURCE TERM

There are two sources of exposure in these analyses. One is the direct gamma-ray exposure to those in the vicinity of a surface pool in the cases of leaks resulting in surface pools. The other is the transport of aerosols downwind. Leaks which remain confined under shielded cover blocks will not produce a significant gamma-ray exposure. Leaks that overflow their confinement or remain confined but without significant shielding (e.g., clean out boxes) will expose nearby onsite personnel to gamma radiation. Transport of aerosols downwind causes exposure to onsite and offsite personnel.

4.1 LEAK VOLUME

One transfer control currently relied upon to mitigate the consequences of a leak is a transfer pump shutdown. However, after the pump is turned off the leak may continue because there is still the potential to drain back and/or siphon waste contained in piping at higher elevations than the leak location. The leak rate should never exceed the level achieved when the pump was running (i.e., 20 gpm), but for conservatism it is not assumed to be less. In these analyses of leaks in COBs, the drain leak is assumed to be identical to the pumped leak rate (20 gpm).

The COB analysis assumes that the transfer lines are constructed of 3 in schedule 40 pipe which holds a liquid volume of 0.384 gal/ft. The longest length of transfer pipe currently under consideration is 27,776 ft (HNF 1998cb). This analysis conservatively assumes that 100% of the contents of an assumed length of 3 inch schedule 40 pipe drains back through the leak at a rate of 20 gpm. This analysis is conservative for transfer lines of smaller inside diameter.

The total leak volume for COB cases includes the amount leaked before leak detection and pump shutdown (i.e. 20 gpm for 30 minutes) and the drain back volume. It is slightly conservative to assume that no waste remains confined (i.e. ignore the 50 gallon holdup in the COB) and that all waste contributes to a surface pool. Consistent with this assumption is that there is no significant volume leaked prior to leak detection, or that leak detection is practically instantaneous. In the case of the COB, it is assumed that the leak detector is 2 inches above the

floor. This corresponds to a volume of about 5 gallons, so leak detection should occur in about 15 seconds (5 gal/20 gal/min x 60 s/min).

For the cases of leaks inside pits, the confinement structure is large and there is a significant leak volume needed for leak detection. Additionally, a leak rate much lower than 20 gpm is sufficient to saturate the pit volume with aerosol. Therefore, rapid leak detection is not assured. However, consequences are calculated conservatively by assuming that 100% of the pit volume is displaced to the environment within 1 hour. Therefore, as long as the leak remains confined, neither leak detection or onsite worker evacuation is credited. For additional analyses, the reader may also refer to the mitigated leak scenario analyzed in Hall (1996c) which was done for the 241-AP valve pit.

There are two leak quantities to consider. The first is for the onsite MEI. His/her exposure is limited to one hour. The second is for the offsite MEI whose exposure period is 24 hours. For simplicity, doses for the 1 hr and 24 hr exposures are conservatively calculated for the maximum pool dimensions obtained at 1 and 24 hours, respectively. For the leaks in a COB, the onsite MEI is exposed to the aerosols from the SC and the surface pool and the gamma from the pool during one hour. The offsite MEI is exposed to the 600 gal pumped out plus the drain back quantity within 24 hours. For the pit leak cases, both the onsite and offsite MEI exposure period is less than one hour.

4.2 GAMMA-RAY EXPOSURE

For the COB leak cases, a conservative gamma-ray exposure estimate is made assuming an idealistic case of a circular pool with an onsite receptor located 100 m from its center. This approach is typical of most TWRS FSAR supporting analyses (Hall 1996a, Hall 1996b, Van Vleet 1997) and meets the definition of onsite maximum exposed individual (MEI) in HNF-PRO-517. Of course, the actual spill shape would depend upon local soil elevations and conditions.

The area of the source depends upon the amount of spreading assumed. Even in the ideal case of a perfectly flat area, this would be a function of waste viscosity, surface porosity and moisture content, ambient temperature, etc. A spreading factor of 8.7 ft^{-1} has been used in a number of TWRS FSAR supporting analyses (Hall 1996a, Van Vleet 1997). This spreading factor was calculated by dividing the surface area of contaminated soil by the estimated spill volume of an actual event. The event occurred at Hanford S farm in 1973 where an estimated 8,600 gal of liquid waste spilled onto 10,000 ft^2 of soil surface (ARH-2977 RD 1974). The depth of soil contamination varied between 2 in and 18 in.

It is typically assumed that there is no immediate infiltration into the soil due to the possibility of ice or salt formation when a saturated waste solution comes into contact with a colder environment. The presence of blacktop or concrete surfaces could also promote formation of a surface pool. This is a conservative assumption because assuming the waste infiltrates the soil reduces the gamma-ray shine by approximately a factor of 4 (assuming a void fraction of

0.4). Due to the fact that the exact location of the leak can not be predicted, nor can the ambient or surface condition be known, no credit for infiltration is taken.

4.3 EXPOSURE DUE TO INHALATION OF RESPIRABLE AEROSOLS

Respirable sized liquid aerosols can be created any time liquid drops are exposed to shear forces. The types of releases that have typically been considered for waste transfers have been categorized as a spray, splash and splatter, or entrainment due to wind. The latter case is actually based on measurements from ponds experiencing wave action which is another form of splash and splatter. The dominant mechanism by far is a spray. All such analyses of unmitigated spray releases of Hanford tank waste directly into the environment yield unacceptable results. These analyses are very conservative. They usually assume maximum pressures, a viscosity equal to that of water, optimum crack widths, and take no credit for plugging due to suspended solids. Nevertheless, it is difficult to prove these optimal conditions can not exist. Hence it has already been concluded that a spray release directly into the atmosphere must always be prevented or mitigated by a confinement barrier. See Section 2.0.

4.3.1 Aerosol Generation Due to Splashing and Splattering

TWRS AB supporting analyses have also made use of a splash/splatter source term to represent liquid waste falling onto a surface out in the open. Hall (1996a) makes use of a respirable release fraction (RRF) of 4E-5 taken from Section 3.2.3.2 of DOE (1994) which is the recommended value for slurries based on a 1 liter sample dropped from a height of 3 m. Jones (1998) used a RRF of 5E-7 taken from the same reference but for a 1 L UNH solution dropped from a height of 1 m. Himes (1997) uses an Archimedes relationship to calculate the respirable aerosol from a falling vertical jet of liquid from height H. Although the application of these values yield small aerosol quantities in comparison to an open spray, it can become a dominant factor when the spray release is mitigated.

DOE (1994) referenced measurements are based on one liter or smaller samples and the trend is a decrease in the release fraction for an increase in sample size. It is very conservative to use these values when applying them to large volume releases such as the several thousand gallon releases typically considered in waste transfer consequence analysis.

When mitigation is provided such that these splash and splatter releases occur within a confinement, it is more accurate to base the release on the aerosol escaping the confinement as opposed to the aerosol generation rate. In the event that a confinement overflows, its physical orientation must not allow waste material to spill freely from a height and splatter against the waste below. In Hanford waste transfers, the various pits with cover blocks and boxes with supplemental covers as described in HNF-2329 (HNF 1997) meet this criterion.

Waste overflowing a pit or box and running down a short vertical wall section should not cause the aerosol fractions observed in Mishima's referenced liquid drop studies. Instead, it is proposed that the multitude of aerosol generating mechanisms which occur within such a

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confinement be represented by a value more representative of the quantity escaping the confinement. This is the approach taken in Hall (1996c) which provides a bounding analysis for very large confinement structures.

4.3.2 Aerosol Release from Confinement

An aerosol generator inside a confined space does not have to be efficient in order to saturate the confined volume with aerosols. Such an aerosol generator could result from the splash and splatter of a low velocity stream of waste impacting a wall or piece of equipment. Both the aerosol concentration and particle size distribution are highly transient values.

When the aerosol is generated inside a confined volume, the source term is better defined by the release rate of aerosols from the confinement, rather than the generation rate within the confinement. This is because there are a number of depletion mechanisms occurring which remove aerosols from the air. The more important mechanisms are gravitational settling, coagulation, condensation, and inertial impaction.

The approach taken in many TWRS AB supporting analyses is to base the source term on the volume of air displaced or vented from the confinement and assume that the escaping air contains a quasi-equilibrium respirable aerosol concentration of 100 mg/m³ (Hall 1996a, Jones 1998, Hall 1996b, Van Keuren 1998). The displaced volumes have typically been calculated to be 35-40% of the total due to thermodynamic effects plus the volume of leakage collected in the confinement. This latter volume is based on either the product of leak rate and leak duration, or half of the confinement volume (assuming the source of aerosol generation is covered at that point). Additionally, venting due to natural breathing effects (i.e., wind) is a consideration. Typically, 100% of the confinement volume is assumed to be displaced as a conservative representation of all of these effects. This creates perhaps a counter intuitive result that the larger the confinement, the larger the dose consequence. Larger confinement volumes do not necessarily result in larger doses because one would expect an increased opportunity for aerosol depletion. However, for simplicity this characteristic is ignored.

4.3.2.1 Aerosol Release from Supplemental Cover

Figure 1 shows a standard supplemental COB enclosure. The volume of this structure is 1.2 m³. Surface wind would tend to sweep out aerosols suspended within the enclosure. The higher the wind speed, the higher the release. However, the atmospheric diffusion coefficient is inversely proportional to wind speed and effectively compensates the increase in release rate such that downwind aerosol concentration remains unchanged. The side walls of the enclosure are approximately one inch off the ground. A volumetric exchange rate of 5.9 vol/hr is calculated in Appendix A for this enclosure under low wind speed conditions. For conservatism this analysis assumes a volumetric release rate of 6 vol/hr of aerosol laden air. The escaping air is assumed to have an aerosol concentration of 100 mg/m³. The duration of this release is expected to last until 100% of the transfer line has drained back through the leak at a rate of 20 gpm. To ensure a conservative estimate of the release, the total release duration, T_t, is calculated with the following equation:

$$T_t \text{ (min)} = T_a + T_s + V_d/20 + T_{sc} \qquad \text{(Eqn. 11)}$$

where:

T_a = time for leak detection and alarm (0 sec)
T_s = time required for pump shut down (30 min)
V_d = volume of waste in assumed length of pipe (gal)
T_{sc} = time for Supplemental Cover to release one volume of aerosol (10 min), and
T_t = is limited to 1440 min (24 hours).

4.3.2.2 Aerosol Release from Pits

The waste transfer structures identified to have a volume less than 15 m^3 but not fitted with supplemental covers have been described as typical concrete valve pits with interlocking concrete cover blocks and shield plugs held in place by gravity. The externals walls of the pits have also been described as straight walled and not exceeding a height of more than a couple of feet. This description of the confinement structure meets the three-part criteria listed in Section 2.0, Means of Mitigation. Therefore no supplemental cover is required because the valve pit with cover blocks and shield plugs in place already provides the necessary confinement function in order for consequences to remain bounded by the results reported in here.

As long as the cover blocks and shield plugs are free to float upwards, the internal pressure within the valve pit cannot exceed 2-3 psig because this is the pressure due to the weight of the cover block (e.g., 2 feet high x140 lb./144 in^2 = 2 lb/in^2). The efficiency of a liquid jet at that pressure to generate aerosol is very low and negligible in comparison to the wet entrainment rates assumed in the analysis. Even if the cover blocks were mechanically restrained, a 3 inch-gap ¼ inch wide could easily accommodate a 20 gpm flow rate at 3 psi. Since no special means are available to seal the cover blocks against any significant pressure differential (i.e., > 3 psi), the cracks around the perimeter of the cover blocks are more than sufficient to accommodate the leak without resulting in a high pressure spray.

The exterior walls of a concrete valve pit are typically perpendicular to the ground, do not have a lip or flange, and are usually one to two feet above grade. Should the pit overflow, the waste would exit the cracks in the perimeter of the cover blocks or shield plug, run across to the edge of the valve pit, and down its side onto the ground. This scenario is very much different from the configuration discussed in Section 3.2.3.2 of Mishima's liquid drop studies. These studies involved the dropping of liter quantities of UNH and other solutions onto a hard surface from one or more meters in height. The intent of these studies was to quantify the source term of the subsequent splattering of the liquid onto the floor. This characterization of what would happen in the event a valve pit overflowed is unnecessarily conservative when the geometry of the pit does not create the situation where a free fall could occur. As long as this is the case, then the aerosol releases considered here conservatively represent the consequences of a leak within a small volume structure.

The tops of pits are slightly above grade but the cover blocks are seated within the walls. Thus, surface wind would not impinge directly on joints or spaces. A leak inside a pit could generate aerosols which could then be released by the combined effects of displacement by leaking waste and heating of pit air. Similar to the approach with COB leaks, a simple approach to aerosol release is used. The air escaping the pit is assumed to contain a quasi-equilibrium concentration of aerosol (0.1 gram/m^3). It is further assumed that the entire volume of pit air is released within 1 hour irrespective of the pit volume or leak rate. For example, a 10 m^3 pit would release 1 gram within 1 hour. Thus both the onsite and offsite MEI's are exposed to the entire release quantity within a short amount of time.

Figure 1. Standard Supplemental COB Enclosure
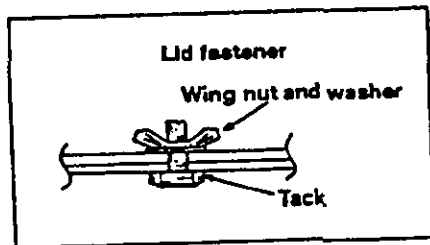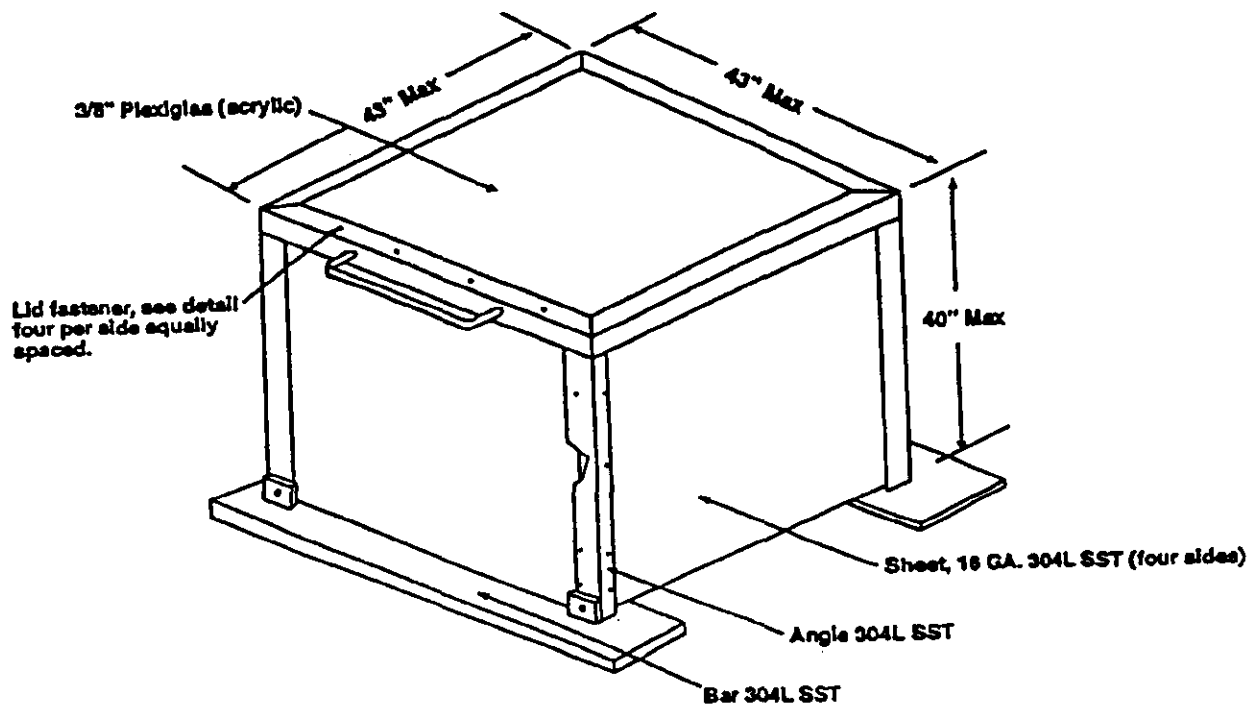
Max = maximum
SST = stainless steel
GA   = gauge
COB = cleanout box

4.3.3   Aerosol Entrainment from Waste Material Exposed to Wind

Because of their small volumes, leaks within COBs are assumed to lead to surface pools. Aerosols generated from wind induced entrainment have also been considered in TWRS AB supporting analyses (Hall 1996a, Jones 1998, Hall 1996b, Van Vleet 1997). The consensus of these analyses is that entrainment would be worse once the spill had dried. But for the one hour onsite MEI exposure period considered in the mitigated analysis, it is safe to assume that wet conditions characterize the spill. What is more difficult to assign is the entrainment rate appropriate for such conditions. The value used in the above referenced analyses is 2E-10 kg/m^2-s. This value was intended to be conservative for the low wind speed χ/Q applied in the dose estimate. It is conservative in that it actually represents wave action occurring in ponds of water with a wind speed of 5 m/s and a fetch of 200 m.

Aerosol generated from wind induced entrainment is evaluated more rigorously herein using the method previously reported in *Refined Consequence Analysis of Subsurface Leaks from TWRS Facilities that Result in a Surface Pool*, TWR-3958, Rev. 1 (Hey 1999). Estimated mass release rates (MRR) from large outdoor ponds are provided in Figure 3-8 of Mishima (1994) as a function of wind speed and wind blown distance across the pond (i.e., fetch). A least squares fit to the data yielded the following equation

$$MRR = 2.14 \times 10^{-15} \, F \, u^{3.762} \qquad \text{(Eqn. 12)}$$

where:

MRR   mass release rate in kg/m^2-s

u   wind speed in m/s,

F   fetch in meters.

The maximum deviation between Equation 12 and the data in Figure 3-8 of Mishima (1994) is $\pm$12% (Hey1999).

In the COB analyses herein, the fetch is taken to be the pool diameter, D. Note that Equation 12 predicts that the MRR is proportional to wind speed raised to the power of 3.762. Thus, high wind speed conditions are predicted to yield much higher mass release rates, a conclusion that agrees with intuition. However, a higher wind speed also results in greater dispersion and would tend to lower downwind aerosol concentrations. Hence, an optimum wind speed exists such that downwind concentrations are at their worst. In order to select a wind speed which is both relatively frequent and representative of an optimal range of entrainment and dispersion conditions, a 95 percentile was chosen of the combined function of MRR * χ/Q. Utilizing the Hanford 200 Area joint frequency (i.e., meteorological) data, analysis showed this condition to be represented by a wind speed of 9.8 m/s and Pasquill stability class D. In other words, for wind/surface entrainment conditions, a wind speed of 9.8 m/s and Pasquill D stability class yields a downwind aerosol concentration which is bounding 95 percent of the time. This approach provides approximately the same degree of conservatism as the 99.5 percent sector χ/Q

typically used in accident analyses for releases independent of wind speed. For further information on this approach, the reader should refer to Hey (1999).

Using a wind speed of 9.8 m/s, Equation 12 is evaluated for a pool diameter D in meters as follows:

$$MRR = 2.14E\text{-}15 \times D \times 5358 \qquad \text{(Eqn 13)}$$
$$= 1.147E\text{-}11 \times D \ kg/m^2\text{-}s$$

The data presented in Mishima (1994) actually represents wave action occurring in ponds of water. This phenomenon is not expected to occur in a relatively small waste spill as compared to a pond. However, it does represent the best available data at this time and the MRR predicted from its use should be a conservative mathematical representation of the TWRS waste spill scenario. Wet entrainment is assumed to occur for the duration of the pipe leak.

After the leak is stopped the pond could be assumed to become static and, without mitigation measures, dry out. TWRS AB analyses have also considered dry entrainment (Jones 1998, Hall 1996b, Van Vleet 1997). All three analyses use a RRF=8.4E-5 from DOE Section 3.2.4.4 (1994) which is applied to the entire spill quantity. Jones (1998) does not include dry entrainment in offsite doses because emergency response procedures are credited with leakage containment and removal (see Section 2.0). The same control is assumed in this mitigated analysis and dry entrainment is not included in any onsite or offsite dose consequence.

5.0 CONSEQUENCE ANALYSIS AND CONCLUSIONS

5.1 MAXIMUM TRANSFER PIPE LENGTHS FOR LEAKS IN CLEANOUT BOXES

This analysis estimates the radiological and toxicological consequences for the six wastes listed in Section 1, namely AWF 67/33, AWF 95/5, DST 67/33, DST 95/5, SST 67/33, and SST 95/5. The cases analyzed determine the longest length of transfer pipe for which the radiological and toxicological consequences will be equal to or less than the consequences reported in Jones (1998) or in the REGs.

5.1.1 Maximum Pipe Lengths for Consequences Less than in Jones (1998)

The radiological and toxicological dose calculation methodology described in Section 3 was used. The individual case calculations were performed with the aid of spreadsheets that are included in Appendix B. To find the longest pipe length for each of the six wastes, an iterative solution process was used. A trial pipe length was selected and inserted in the spreadsheet. In addition, a preliminary value for the total leak duration was selected. This value was typically 2 hours and determines the offsite χ/Q value from Equation 9. The spreadsheet calculates the resulting consequences including a key parameter, the total leak time corresponding to the input

pipe length as shown in Equation 11. A time value less than this total release time is inserted into Equation 9 and a new case is run with the resulting new value of offsite χ/Q. After about 5 iterations, the consequences reach one of the limits from Jones 1998 (as shown in Table 5-1). At this point, the total leak time is evaluated with respect to the input time for the χ/Q calculation. Convergence is obtained when the time value input to Equation 9 for offsite χ/Q is less than the resulting total leak time from Equation 11. For example, for the case of AWF 67/33 waste, the leak time was about 4.1 hours and the time value for χ/Q was 4.0 hours. In all cases, a maximum time of 12 hours was used for determining the offsite χ/Q value even when leak durations were much longer (up to the maximum of 24 hours). This helps ensure that the results are conservative.

The results for all wastes are summarized below. The table compares the consequences to *Calculation Notes for Surface Leak Resulting in Pool, TWRS FSAR Accident Analysis*, WHC-SD-WM-CN-049, Rev. 0-B (Jones 1998).

Table 5-1. Maximum Pipe Lengths for 20 gpm COB Leak
with Consequences within Present Authorization Basis

Waste Type Liquid/Solid	Pipe Length m (feet)	Spill Volume L (gal)	Onsite Dose Sv	Offsite Dose Sv	Onsite Toxicological	Offsite Toxicological
Reference (Jones 1998)	610 (2,000)	5,300 (1,400)	5.1E-3	6.6E-6	1.4E-1	7.5E-4
AWF 67/33	3,400 (11,000)	19,000 (4,900)	4.3E-3	6.6E-6	2.0E-3	1.7E-5
AWF 95/5	23,000 (75,000)	110,000 (29,000)	1.5E-3	4.5E-6	1.6E-3	3.1E-5
DST 67/33	17,000 (55,000)	83,000 (22,000)	1.7E-3	6.6E-6	2.0E-3	8.2E-5
DST 95/5	23,000 (75,000)	110,000 (29,000)	8.5E-4	1.7E-6	1.6E-3	3.1E-5
SST 67/33	23,000 (75,000)	110,000 (29,000)	1.0E-3	4.3E-6	3.1E-3	6.4E-5
SST 95/5	23,000 (75,000)	110,000 (29,000)	4.1E-4	1.1E-6	1.7E-3	2.2E-5

From the table above it is seen that the limiting criterion is the offsite dose. The onsite dose is close to the limit for AWF 67/33 (4.3 versus 5.1) but far from the limit for SST 95/5 (4.1E-4 versus 5.1E-3). The toxicological consequences are far from the limits (about a factor of 9 or more). Four of the six wastes are within the criteria in Jones 1998 for connecting 3-inch schedule 40 pipe lengths of 75,000 feet (14.2 miles). This length is far greater than any in current designs. A 75,000 foot-length corresponds to a drainback volume of 28,800 gallons which is the maximum amount that can be leaked in 24 hours at a leak rate of 20 gpm (20 gpm x

24 hr x 60 min/hr). Thus, longer pipe lengths do not increase the consequences at 24 hours for the offsite MEI.

The 20 gpm leak of AWF 67/33 waste which has the highest Unit Liter Dose values is acceptable for pipe length up to about 11,000 feet. The limiting criterion for the AWF 67/33 waste is the dose to the offsite MEI, 6.6E-6 Sv in Jones 1998. This length is likely to bound the longest transfer pipe length identified up to the present with the exception of the Replacement Cross-Site Transfer System (CSTS) which has a length of about 6.5 miles. For the 11,000 foot-length to be limiting, the pipe would have to either slope along its entire length back to the leak site or be capable of inducing a siphon from the destination tank. This makes the possibility of such a case very improbable.

The 20 gpm leak of DST 67/33 waste (which has the next highest Unit Liter Dose values) is acceptable for pipe length up to about 55,000 feet. Its limiting criterion is also the dose to the offsite MEI, 6.6E-6 Sv. This length is likely to bound the longest transfer pipe length identified up to the present including the RCSTS. For the 55,000 foot-length to be limiting, the pipe would have to either slope along its entire length back to the leak site or be capable of inducing a siphon from the destination tank. This makes such a case very improbable.

It should be noted that the above results for leaks in clean-out boxes are not necessarily limited to cases where the transfer pump is shut off within 30 minutes. If the leak volume is limited to that represented by the pipe length which could drain back, then transfer pump shut off could occur later and still have consequences bounded by those reported above.

Some detailed results for the limiting case of AWF 67/33 waste are shown below in Table 5-2. The table lists the radiological and toxicological consequences by pathway. It is seen that the radiological consequences are due mostly to the release from the Supplemental Cover ("SupCover" in Table 5-2). The spreadsheets for all cases are included in Appendix B.

Table 5-2. Details of Analysis for 20 gpm AWF 67/33 Leak in Cleanout Box

Radiological Consequences							
	Source Terms by Mechanism(L)						
	SupCover	WetResus	Gamma	χ/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		4.92E-05		7.57E-04	3.30E-04	5.62E+05	6.91E-06
	5.14E-04			3.41E-02	3.30E-04	5.62E+05	3.25E-03
Gamma*			1.02E-03				1.02E-03
Total Onsite							4.28E-03
Offsite Inhalation		9.75E-03	NA	4.92E-07	3.30E-04	5.62E+05	8.90E-07
	2.19E-03		NA	1.39E-05	3.30E-04	5.62E+05	5.62E-06
Ingestion		9.75E-03		4.92E-07		2.73E+00	1.31E-08
	2.19E-03			1.39E-05		2.73E+00	8.29E-08
Total Offsite							6.60E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	SupCover	WetResus	SupCover	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.43E-07	1.37E-08			1.57E-07	1.26E+04	1.98E-03
Offsite	1.43E-07	1.37E-08	1.43E-07	1.13E-07	2.56E-07	6.83E+01	1.75E-05

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5.1.2 Maximum Pipe Lengths for Consequences Less than REGs

Two additional cases for leaks into COBs were run to determine the longest transfer pipe length for which the consequences will be within the REGs. Only the cases for AWF 67/33 and DST 67/33 needed to be run because these were the only cases restricted by Jones (1998) to a transfer pipe length less than 75,000 feet. The same analysis process using spreadsheets as described in section 5.1.1 was used. The results for all wastes are summarized below.

Table 5-3. Maximum Pipe Lengths for 20 gpm COB Leak Consequences within REGs

Waste Type Liquid/Solid	Pipe Length m (feet)	Spill Volume L (gal)	Onsite Dose Sv	Offsite Dose Sv	Onsite Toxicological	Offsite Toxicological
SAR-067 Table 4.3.1-1	NA	NA	5.0E-3	1.0E-3	1.0	1.0
AWF 67/33	23,000 (75,000)	110,000 (29,000)	4.3E-3	2.9E-5	2.0E-3	1.2E-4
AWF 95/5	23,000 (75,000)	110,000 (29,000)	1.5E-3	4.5E-6	1.6E-3	3.1E-5
DST 67/33	23,000 (75,000)	110,000 (29,000)	1.7E-3	9.2E-6	2.0E-3	1.2E-4
DST 95/5	23,000 (75,000)	110,000 (29,000)	8.5E-4	1.7E-6	1.6E-3	3.1E-5
SST 67/33	23,000 (75,000)	110,000 (29,000)	1.0E-3	4.3E-6	3.1E-3	6.4E-5
SST 95/5	23,000 (75,000)	110,000 (29,000)	4.1E-4	1.1E-6	1.7E-3	2.2E-5

From the table above it is seen that all six waste types are within the REGs for the longest transfer pipe length of 75,000 feet (14.2 miles). This length is far greater than any in current designs. A 75,000 foot-length corresponds to a drainback volume of 28,800 gallons which is the maximum amount that can be leaked in 24 hours at a leak rate of 20 gpm (20 gpm x 24 hr x 60 min/hr). Thus, longer pipe lengths do not increase the consequences at 24 hours for the offsite MEI.

As in section 5.1.1, it should be noted that the above results for leaks in clean-out boxes are not necessarily limited to cases where the transfer pump is shut off within 30 minutes. If the leak volume is limited to that represented by the pipe length which could drain back, then transfer pump shut off could occur later and still have consequences bounded by those reported above.

5.2 MAXIMUM VOLUMES FOR LEAKS IN PITS

This analysis estimates the radiological and toxicological consequences for the six wastes listed in Section 1. The analyses were performed using as criteria the onsite and offsite radiological and toxicological doses for Anticipated Events in the REGs and the limits in Ryan (1999). The cases analyzed determine the largest pit volume for which the radiological and toxicological consequences will be equal to or less than the the REGs or, for the case of AWF waste, less than the consequences allowed by the Authorization Basis which is based on Ryan (1999).

The radiological and toxicological dose calculation methodology described in Section 3 was used. The individual case calculations were performed with the aid of spreadsheets that are included in Appendix B. To find the maximum pit volume for each of the six wastes, a simple iterative solution process was used. A trial pit volume was selected and inserted in the spreadsheet. After about 3 iterations, the consequences reach one of the limits. The spreadsheets for all cases are provided in Appendix B.

5.2.1 Maximum Pit Volumes for AWF Waste Leak Consequences Less than the AB

The results for the two AWF cases run against the limits in Ryan (1999) are summarized in Table 5-4 below.

Table 5-4. Maximum Pit Volumes for AWF Waste Leak Consequences Less than the Authorization Basis

Waste Type Liquid/Solid	Pit Volume m^3 (ft^3)	Maximum Spill Volume L (gal)	Onsite Dose Sv	Offsite Dose Sv	Onsite Toxicological	Offsite Toxicological
Ryan (1999)	NA	NA	4.1E-2	3.7E-5	8.1E-2	4.2E-4
AWF 67/33	91 (3,200)	91,000 (24,000)	4.1E-2	3.5E-5	2.3E-2	1.2E-4
AWF 95/5	390 (14,000)	390,000 (100,000)	2.7E-2	2.3E-5	8.1E-2	1.4E-4

It is seen from the table above that the dose to the onsite MEI is limiting for a leak of AWF 67/33 into a pit. In contrast, the onsite toxicological dose is limiting for a leak of AWF 95/5 into a pit. These results are due to the assumption that the entire pit air volume is released within one hour and no additional release occurs. The pit volumes above may be compared to the volume of the largest pit in use today, the 241-AP pit with a volume of 74.9 m^3 (DOE 1991, Himes 1997). The maximum pit volumes for AWF wastes are significantly larger than 74.9 m^3 (241-AP).

It should be noted that the above results for leaks within pits are not sensitive to any particular leak rate assumption. If the spill volume is limited to that represented by the pit volume, then any pit leak rate scenario will have consequences bounded by those reported above.

5.2.2   Maximum Pit Volumes for Consequences Less than the REGs

A second set of cases were run to determine the largest pit volume for which the consequences will be within the REGs. The same analysis process using spreadsheets as described in section 5.2.1 was used. The results for all cases are summarized below.

Table 5-5. Maximum Pit Volumes for Consequences within REGs

Waste Type Liquid/Solid	Pit Volume m^3 (ft^3)	Maximum Spill Volume L (gal)	Onsite Dose Sv	Offsite Dose Sv	Onsite Toxicological	Offsite Toxicological
SAR-067 Table 4.3.1-1	NA	NA	5.0E-3	1.0E-3	1.0	1.0
AWF 67/33	11 (3,90)	11,000 (2,900)	5.0E-3	4.2E-6	2.8E-3	1.5E-5
AWF 95/5	72 (2,500)	72,000 (19,000)	5.0E-3	4.2E-6	1.5E-2	2.5E-5
DST 67/33	35 (1,200)	35,000 (9,300)	5.0E-3	4.2E-6	8.8E-3	4.7E-5
DST 95/5	190 (6,700)	190,000 (50,000)	4.9E-3	4.1E-6	3.9E-2	6.6E-5
SST 67/33	78 (2,800)	78,000 (21,000)	5.0E-3	4.4E-6	3.0E-2	5.6E-5
SST 95/5	290 (10,000)	290,000 (76,000)	5.0E-3	4.3E-6	6.4E-2	7.1E-5

It is seen from the table above that the dose to the onsite MEI is limiting for pit leaks. This is due to the assumption that the entire pit air volume is released within one hour and no additional release occurs. The pit volumes above may be compared to the volume of the largest pit in use today, the 241-AP pit with a volume of 74.9 m^3 (DOE 1991, Himes 1997). The maximum pit volumes for AWF 67/33 (11 m^3) and DST 67/33 (35 m^3) are significantly smaller than 74.9 m^3 (241-AP). However, it is possible to transfer the DST waste through lines that do not have pits with volumes larger than 35 m^3.

It should be noted that the above results for leaks within pits are not sensitive to any particular leak rate assumption. If the spill volume is limited to that represented by the pit volume, then any pit leak rate scenario will have consequences bounded by those reported above.

5.3   CONCLUSIONS

As stated in Section 1.0, two kinds of evaluations are needed to provide a bounding analysis of mitigated waste transfer leak scenarios. One is a spill resulting in a surface pool from

which gamma-ray exposure and entrainment due to wind occurs. The other is a leak into a confinement structure such as a valve pit which results in the release of aerosols as the pit air is displaced. Acceptable means of mitigation are identified in Section 2.0.

5.3.1 Leaks in Cleanout Boxes that form a Surface Pool

For leaks into a COB that form a surface pool, onsite exposure is limited via leak detection and emergency response actions to evacuate onsite personnel within 1 hour. Offsite exposure could increase even after transfer pump shutdown due to continued leakage as long as the transfer pipe continues to drain. The length of pipe which could drain completely yet still have offsite consequences which are bounded by Jones 1998 is reported in Table 5-1 assuming the transfer pipe is 3-inch schedule 40 pipe. Although the calculation assumed transfer pump shutdown occurred 30 minutes after onset of leakage, this timing is not critical as long as the total volume spilled remains below the spill volume reported in Table 5-1. The primary differences between this analysis and Jones 1998 is the use of a consistent wind speed for both entrainment and atmospheric dispersion as discussed in Section 4.3.3, and the elimination of the splash/splatter source term (see Section 4.3.2). The two wastes that are most restrictive in terms of allowable transfer pipe length in comparison to the Jones (1998) data are AWF 67/33 and DST 67/33 with maximum lengths of 11,000 feet and 55,000 feet, respectively (see Table 5-1). For 20 gpm leaks into a COB, all six waste types have consequences within the REGS for pipe lengths up to 75,000 feet, which corresponds to the total volume that can be drained in a 24-hour period at 20 gpm (see Table 5-3).

5.3.2 Leaks in Pits

For the leak in a pit, the pit volume is the critical parameter which defines exposure. Since the pit is not air tight, aerosols can escape via a number of processes. This aerosol release is simplistically assumed to be directly proportional to the pit volume. Leak detection, leak rates and transfer pump shutdown are not critical to onsite and offsite exposure because the entire pit volume is assumed to be displaced in less than an hour. The analysis assumes that the pit does not overflow. This would be true as long as the spill volume remains less then the pit volume. In the event a pit did overflow, a pressurized spray would not be generated due to the uplifting of the cover blocks as discussed in Section 4.3.2.2. Also, aerosol generation through a splash and splatter mechanism would not be expected due to the "near grade" top of the pit and geometry not conducive to a free fall spill. This is also discussed in Section 4.3.2.2.

The Safety Basis that provides the current Authorization Basis for AWF wastes is provided in *FSAR Transition Spray Leak Analysis, Rev. 0*, HNF-5147 (Ryan 1999). The AWF 67/33 and AWF 95/5 waste are at the limits in Ryan (1999) for pit volumes of 91 and 390 m^3, respectively, which are larger than the largest pit (74.9 m^3). These results are provided in Table 5-4.

The DST 95/5, SST 67/33, and SST 95/5 wastes are all within the REGs for leaks in pits larger than 74.9 m^3. The DST 67/33 waste is within the REGs for a pit volume of 35 m^3. The AWF 67/33 waste is within the REG limits for a pit volume of 11m^3. Leaks into pits with consequences which are bounded by the REGs are reported in Table 5-5.

In 4 out of 6 cases (AWF 67/33, AWF 95/5, DST 67/33, and SST 67/33) the bounding pit volume is less than the bounding surface pool volume. Hence, this same bounding surface pool volume leaked into the bounding pit would result in an overflow. However, this would not affect onsite consequences because assuming a 20 gpm leak even the smallest bounding pit (11 m^3) would take longer than 2 hours to fill, by which time the onsite worker would be evacuated.

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APPENDIX A – Calculation of Volumetric Air Exchange Rate for COB

An approximate air exchange rate is calculated for a supplementary cover having the dimensions shown in Figure 1. The premise of this calculation is that wind will blow in an opening on one side of the enclosure, mix thoroughly with the air inside the enclosure, and exit the opposite side through a similar opening. The opening shown in Figure 1 has an area A of 0.0277 m^2 (~43 in^2) and the enclosure volume V is 1.2 m^3.

An approximate ground level wind speed is calculated using a power law formula (Hanna 1982):

$$u = u_{10}(z/10)^p$$

where z is height in meters and u_{10} is the observed wind speed at a height of 10 m. The power factor p is taken to represent class F wind speed for rural conditions and is assigned a value of 0.55. Using this formula for an observed 10 m wind speed of 0.89 m/s, a wind speed of 0.0707 m/s is calculated for height of 0.1 m. This should conservatively represent the wind speed at the face of the enclosure opening which is approximately one inch above the ground.

The flow rate through the enclosure under these conditions is given by the formula:

$$
\begin{aligned}
w &= u \ A \\
&= (0.0707 \text{ m/s})(0.0277 \text{ m}^2) \\
&= 0.00196 \text{ m}^3/s
\end{aligned}
$$

The volume exchange rate is then:

$$
\begin{aligned}
R &= w/V \\
&= (0.00196 \text{ m}^3/s)/(1.2 \text{ m}^3) \\
&= 0.00163 \text{ vol/s} \\
&= 5.9 \text{ vol/hr}
\end{aligned}
$$

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APPENDIX B - Spreadsheet Consequence Calculations

The following pages include spreadsheet results representing various waste compositions, pit volumes and transfer line lengths. Unit liter doses, toxic sum of fractions, and Bremsstrahlung gamma-ray spectra for Sr-90 were taken from Van Keuren (1996a, 1996b). Onsite exposures due to material entrainment from a surface pool use the χ/Q based on a wind speed of 9.8 m/s and Class D conditions for conservatism in the aerosol entrained by wind acting on the surface pool. The release rate per unit area is based on a correlation that is a function of wind speed and pool diameter (for the fetch). Exposures due to material released from a Supplemental Cover on the Cleanout Box use for conservatism a plume meander corrected χ/Q for a wind speed of 1 m/s and Class F conditions.

Gamma-ray shine doses are derived using the ratio of the pool volume to the 1,200 gal spill assumed in the reference case. The Microshield™ and Microskyshine™ output files for the reference case are provided in Appendix C. This is appropriate since the onsite MEI distance is far enough (i.e., 100 m) to cause the relationship between source quantity and dose to be approximately linear. Gamma-ray shine doses are also ratioed by the Cs-137 pool inventory against the base case inventory since Cs-137 dominates the gamma-ray shine dose.

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67/33 AWF Waste and 20 gpm Leak

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AWF Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s L)
AWF Liquids	1.4E+03	9.2E-02
AWF Solids	1.7E+06	8.1E+00
67/33 Composite	5.6E+05	2.7E+00

AWF Continuous Release SOF Multipliers (s/L) (same as DST)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
AWF Liquids	1.0E+04	8.4E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
AWF Solids	1.8E+04	1.9E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
67/33 Composite	1.3E+04	6.8E+01	1.6E+03	1.1E+01	3.5E+02	1.3E+00

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	1.39E-05

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	9.13E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.55E+00

Breathing Rates (m3/s)

light activity	3.3E-04	
24-hr average	3.3E-04	Note LA rate

Logarithmic Interpolated X/Q 2.12E-05
Time (hr)= 4 1.24E-07
X/Q = 1.39E-05

67/33 AWF Waste and 20 gpm Leak

Pipe Length (feet)   11,200.0

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Source Term

Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm		given
Time for leak detector alarm	0.00E+00 min		given
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	6.00E+02 gal		
Drainback pipe length	1.12E+04 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	4.30E+03 gal		
Drainback leak rate	2.00E+01 gpm		
Total spill volume in 24hours	4.90E+03 gal	1.85E+04 L	
Total spill duration(max=24hr)	2.45E+02 min	1.47E+04 s	4.08E+00 hr
Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	1.20E+03 gal	4.54E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	1.40E+03 ft2	1.30E+02 m2	
Pool radius	2.11E+01 ft	6.43E+00 m	
Wet resuspension flux		1.47E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.37E-08 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		4.92E-05 L	onsite evac. control
Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	4.90E+03 gal	1.85E+01 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	5.70E+03 ft2	5.30E+02 m2	
Pool radius	4.26E+01 ft	1.30E+01 m	
Wet resuspension flux		2.98E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.13E-07 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		9.75E-03 L	Leakage containment
Release from Supplementary Cover			& removal control
Confined volume	4.23E+01 ft3	1.20E+00 m3/vol	limiting assumption
Confined volume exchange rate		6.00E+00 vol/hr	reasonable assumption
Confined volume aerosol concentration		1.00E+02 mg/m3	reasonable assumption
Aerosol release rate from confined volume		1.43E-07 L/s	
Aerosol release from 1 hr confined volume release		5.14E-04 L	6.00E+01 minutes
Aerosol release from 24 hr confined volume release		2.19E-03 L	2.55E+02 minutes
Summary of Releases and Rates			
Peak 1 hr aerosol release rate		1.57E-07 L/s	
Peak 24 hr aerosol release rate		2.56E-07 L/s	
Total 1 hr aerosol release		5.64E-04 L	
Total 24 hr aerosol release		1.19E-02 L	

67/33 AWF Waste and 20 gpm Leak

One hour leak quantity =	1,200 gal	Total time	4.08E+00 hours	
24 hour leak quantity =	4,901 gal		2.45E+02 minutes	
Transfer Line Length =	11,200 ft		2.1 miles	4 hr for X/Q
		Line vol	4301 gallons	

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)
Inhalation	3.26E-03	6.51E-06
Ingestion	NA	9.60E-08
Gamma-ray	1.02E-03	NA
Total	4.28E-03	6.60E-06
Anticipated Guideline	5.00E-03	1.00E-03

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	1.98E-03		1.75E-05	
Guideline	1.00E+00		1.00E+00	

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Inhalation Dose-Ratio of SC Release to Wind Entrainment			
Onsite Receptor,1hour		470.5	
Offsite Receptor, 24 hr		6.3	

67/33 AWF Waste and 20 gpm Leak
Summary of Results   Pipe Length (feet)   11,200.0

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*
Radiological	Onsite	4.3E-03	5.0E-03	5.1E-03
	Offsite	6.6E-06	1.0E-03	6.6E-06
Toxicological	Onsite	2.0E-03	1.0E+00	1.4E-01
	Offsite	1.7E-05	1.0E+00	7.5E-04

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Radiological Consequences							
	Source Terms by Mechanism(L)						
		SupCover	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite	Inhalation		4.92E-05		7.57E-04	3.30E-04	5.62E+05	6.91E-06
		5.14E-04			3.41E-02	3.30E-04	5.62E+05	3.25E-03
	Gamma*			1.02E-03				1.02E-03
	Total							4.28E-03
Offsite	Inhalation		9.75E-03	NA	4.92E-07	3.30E-04	5.62E+05	8.90E-07
		2.19E-03		NA	1.39E-05	3.30E-04	5.62E+05	5.62E-06
	Ingestion		9.75E-03		4.92E-07		2.73E+00	1.31E-08
		2.19E-03			1.39E-05		2.73E+00	8.29E-08
	Total							6.60E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	SupCover	WetResus	SupCover	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.43E-07	1.37E-08			1.57E-07	1.26E+04	1.98E-03
Offsite	1.43E-07	1.37E-08	1.43E-07	1.13E-07	2.56E-07	6.83E+01	1.75E-05

File:TWR3738Rev1/3738R1AWF67

95/5 AWF Waste and 20 gpm Leak

File: TWR3738Rev1/3738R1AWF95

AWF Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s L)
AWF Liquids	1.4E+03	9.2E-02
AWF Solids	1.7E+06	8.1E+00
95/5 Composite	8.6E+04	4.9E-01

AWF Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
AWF Liquids	1.0E+04	8.4E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
AWF Solids	1.8E+04	1.9E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
95/5 Composite	1.0E+04	1.7E+01	8.8E+02	8.7E+00	2.3E+02	7.3E-01

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	7.07E-06

Breathing Rates (m3/s)

light activity	3.3E-04
24-hr average	3.3E-04

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	8.85E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.50E+00

Logarithmic Interpolated Chi/Q		2.12E-05
Time (hr)=	12	1.24E-07
X/Q =	7.07E-06	

95/5 AWF Waste and 20 gpm Leak

Pipe Length (feet)   75,000.0

File:TWR3738Rev1/3738R1AWF95

Source Term

Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm		given
Time for leak detector alarm	0.00E+00 min		given
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	6.00E+02 gal		
Drainback pipe length	7.50E+04 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	2.88E+04 gal		
Drainback leak rate	2.00E+01 gpm		
Total spill volume in 24hours	2.88E+04 gal	1.09E+05 L	
Total spill duration(max=24hr)	1.44E+03 min	8.64E+04 s	2.40E+01 hr
Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	1.20E+03 gal	4.54E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	1.40E+03 ft2	1.30E+02 m2	
Pool radius	2.11E+01 ft	6.43E+00 m	
Wet resuspension flux		1.47E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.37E-08 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		4.92E-05 L	onsite evac. control
Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	2.88E+04 gal	1.09E+02 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	3.35E+04 ft2	3.12E+03 m2	
Pool radius	1.03E+02 ft	3.15E+01 m	
Wet resuspension flux		7.22E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.61E-06 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		1.39E-01 L	Leakage containment
Release from Supplementary Cover			& removal control
Confined volume	4.23E+01 ft3	1.20E+00 m3/vol	limiting assumption
Confined volume exchange rate		6.00E+00 vol/hr	reasonable assumption
Confined volume aerosol concentration		1.00E+02 mg/m3	reasonable assumption
Aerosol release rate from confined volume		1.43E-07 L/s	
Aerosol release from 1 hr confined volume release		5.14E-04 L	6.00E+01 minutes
Aerosol release from 24 hr confined volume release		1.23E-02 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak 1 hr aerosol release rate		1.57E-07 L/s	
Peak 24 hr aerosol release rate		1.75E-06 L/s	
Total 1 hr aerosol release		5.64E-04 L	
Total 24 hr aerosol release		1.51E-01 L	

95/5 AWF Waste and 20 gpm Leak

One hour leak quantity =	1,200 gal	Total time	2.40E+01 hours
24 hour leak quantity =	28,800 gal		1.44E+03 minutes
Transfer Line Length =	75,000 ft	14.2 miles	12 hr for X/Q
	Line vol.	28801 gallons	

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)
Inhalation	5.01E-04	4.43E-06
Ingestion	NA	7.66E-08
Gamma-ray	9.89E-04	NA
Total	1.49E-03	4.51E-06
Anticipated Guideline	5.00E-03	1.00E-03

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	1.63E-03		3.06E-05	
Guideline	1.00E+00		1.00E+00	

File:TWR3738Rev1/3738R1AWF95

Inhalation Dose-Ratio of SC Release to Wind Entrainment			
Onsite Receptor,1hour		470.5	
Offsite Receptor, 24 hr		1.3	

95/5 AWF Waste and 20 gpm Leak
Summary of Results   Pipe Length (feet)   75,000.0

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*
Radiological	Onsite	1.49E-03	5.00E-03	5.10E-03
	Offsite	4.51E-06	1.00E-03	6.60E-06
Toxicological	Onsite	1.63E-03	1.00E+00	1.40E-01
	Offsite	3.06E-05	1.00E+00	7.50E-04

File:TWR3738Rev1/3738R1AWF95

Radiological Consequences							
	Source Terms by Mechanism(L)						
	SupCover	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		4.92E-05		7.57E-04	3.30E-04	8.63E+04	1.06E-06
	5.14E-04			3.41E-02	3.30E-04	8.63E+04	5.00E-04
Gamma*			9.89E-04				9.89E-04
Total							1.49E-03
Offsite Inhalation		1.39E-01	NA	4.92E-07	3.30E-04	8.63E+04	1.95E-06
	1.23E-02		NA	7.07E-06	3.30E-04	8.63E+04	2.48E-06
Ingestion		1.39E-01		4.92E-07		4.92E-01	3.37E-08
	1.23E-02			7.07E-06		4.92E-01	4.29E-08
Total							4.51E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	SupCover	WetResus	SupCover	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.43E-07	1.37E-08			1.57E-07	1.04E+04	1.63E-03
Offsite	1.43E-07	1.37E-08	1.43E-07	1.61E-06	1.75E-06	1.75E+01	3.06E-05

File:TWR3738Rev1/3738R1AWF95

67/33 DST Waste 20 gpm Leak

File TWR3738Rev1/3738R1DST67

DST Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s-L)
DST Liquids	6.1E+03	6.8E-02
DST Solids	5.3E+05	4.8E-01
67/33 Composite	1.8E+05	2.0E-01

DST Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency Onsite	Offsite	Unlikely Frequency Onsite	Offsite	Extremely Unlikely Frequency Onsite	Offsite
DST Liquids	1.0E+04	8.4E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
DST Solids	1.8E+04	1.9E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
67/33 Composite	1.3E+04	6.8E+01	1.6E+03	1.1E+01	3.5E+02	1.3E+00

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	7.07E-06

Breathing Rates (m3/s)

light activity	3.3E-04
24-hr average	3.3E-04

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	5.90E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.00E+00

Logarithmic Interpolated X/Q

Logarithmic Interpolated X/Q		2.12E-05
Time (hr)=	12	1.24E-07
X/Q =	7.07E-06	

67/33 DST Waste 20 gpm Leak

Pipe Length (feet)   55,000.0
File:TWR3738Rev1/3738R1DST67

Source Term

Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm		given
Time for leak detector alarm	0.00E+00 min		given
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	6.00E+02 gal		
Drainback pipe length	5.50E+04 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	2.11E+04 gal		
Drainback leak rate	2.00E+01 gpm		
Total spill volume in 24hours	2.17E+04 gal	8.22E+04 L	
Total spill duration(max=24hr)	1.09E+03 min	6.52E+04 s	1.81E+01 hr
Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	1.20E+03 gal	4.54E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	1.40E+03 ft2	1.30E+02 m2	
Pool radius	2.11E+01 ft	6.43E+00 m	
Wet resuspension flux		1.47E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.37E-08 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		4.92E-05 L	onsite evac. control
Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	2.17E+04 gal	8.22E+01 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	2.53E+04 ft2	2.35E+03 m2	
Pool radius	8.97E+01 ft	2.74E+01 m	
Wet resuspension flux		6.27E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.05E-06 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		9.10E-02 L	Leakage containment
Release from Supplementary Cover			& removal control
Confined volume	4.23E+01 ft3	1.20E+00 m3/vol	limiting assumption
Confined volume exchange rate		6.00E+00 vol/hr	reasonable assumption
Confined volume aerosol concentration		1.00E+02 mg/m3	reasonable assumption
Aerosol release rate from confined volume		1.43E-07 L/s	
Aerosol release from 1 hr confined volume release		5.14E-04 L	6.00E+01 minutes
Aerosol release from 24 hr confined volume release		9.39E-03 L	1.10E+03 minutes
Summary of Releases and Rates			
Peak 1 hr aerosol release rate		1.57E-07 L/s	
Peak 24 hr aerosol release rate		1.20E-06 L/s	
Total 1 hr aerosol release		5.64E-04 L	
Total 24 hr aerosol release		1.00E-01 L	

67/33 DST Waste 20 gpm Leak

One hour leak quantity =		1,200 gal	Total time	1.81E+01 hours	
24 hour leak quantity =		21,720 gal		1.09E+03 minutes	
Transfer Line Length =		55,000 ft	10.4 miles		12 hr for X/Q
			Line vol.	21120 gallons	

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)
Inhalation	1.04E-03	6.57E-06
Ingestion	NA	2.27E-08
Gamma-ray	6.59E-04	NA
Total	1.70E-03	6.59E-06
Anticipated Guideline	5.00E-03	1.00E-03

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	1.98E-03		8.17E-05	
Guideline	1.00E+00		1.00E+00	

File:TWR3738Rev1/3738R1DST67

Inhalation Dose-Ratio of SC Release to Wind Entrainment			
Onsite Receptor,1hour		470.5	
Offsite Receptor, 24 hr		1.5	

67/33 DST Waste 20 gpm Leak
Summary of Results   Pipe Length (feet)   55,000.0

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*
Radiological	Onsite	1.70E-03	5.00E-03	5.10E-03
	Offsite	6.59E-06	1.00E-03	6.60E-06
Toxicological	Onsite	1.98E-03	1.00E+00	1.40E-01
	Offsite	8.17E-05	1.00E+00	7.50E-04

File:TWR3738Rev1/3738R1DST67

Radiological Consequences								
	Source Terms by Mechanism(L)							
		SupCover	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite	Inhalation		4.92E-05		7.57E-04	3.30E-04	1.79E+05	2.20E-06
		5.14E-04			3.41E-02	3.30E-04	1.79E+05	1.04E-03
	Gamma*			6.59E-04				6.59E-04
	Total							1.70E-03
Offsite	Inhalation		9.10E-02	NA	4.92E-07	3.30E-04	1.79E+05	2.64E-06
		9.39E-03		NA	7.07E-06	3.30E-04	1.79E+05	3.92E-06
	Ingestion		9.10E-02		4.92E-07		2.04E-01	9.13E-09
		9.39E-03			7.07E-06		2.04E-01	1.35E-08
	Total							6.59E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	SupCover	WetResus	SupCover	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.43E-07	1.37E-08			1.57E-07	1.26E+04	1.98E-03
Offsite	1.43E-07	1.37E-08	1.43E-07	1.05E-06	1.20E-06	6.83E+01	8.17E-05

File:TWR3738Rev1/3738R1DST67

95/5 DST Waste 20 gpm Leak

File:TWR3738Rev1/3738R1DST95

DST Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s L)
DST Liquids	6.1E+03	6.8E-02
DST Solids	5.3E+05	4.8E-01
95/5 Composite	3.2E+04	8.9E-02

DST Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
DST Liquids	1.0E+04	8.4E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
DST Solids	1.8E+04	1.9E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
95/5 Composite	1.0E+04	1.7E+01	8.8E+02	8.7E+00	2.3E+02	7.3E-01

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	7.07E-06

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	5.90E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.00E+00

Breathing Rates (m3/s)

light activity	3.3E-04
24-hr average	3.3E-04

Logarithmic Interpolated X/Q   2.12E-05

Time (hr)=	12	1.24E-07
X/Q =	7.07E-06	

95/5 DST Waste 20 gpm Leak

Pipe Length (feet)   75,000.0
File:TWR3738Rev1/3738R1DST95

Source Term

Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm		given
Time for leak detector alarm	0.00E+00 min		given
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	6.00E+02 gal		
Drainback pipe length	7.50E+04 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	2.88E+04 gal		
Drainback leak rate	2.00E+01 gpm		
Total spill volume in 24hours	2.88E+04 gal	1.09E+05 L	
Total spill duration(max=24hr)	1.44E+03 min	8.64E+04 s	2.40E+01 hr
Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	1.20E+03 gal	4.54E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	1.40E+03 ft2	1.30E+02 m2	
Pool radius	2.11E+01 ft	6.43E+00 m	
Wet resuspension flux		1.47E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.37E-08 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		4.92E-05 L	onsite evac. control
Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	2.88E+04 gal	1.09E+02 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	3.35E+04 ft2	3.12E+03 m2	
Pool radius	1.03E+02 ft	3.15E+01 m	
Wet resuspension flux		7.22E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.61E-06 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		1.39E-01 L	Leakage containment
Release from Supplementary Cover			& removal control
Confined volume	4.23E+01 ft3	1.20E+00 m3/vol	limiting assumption
Confined volume exchange rate		6.00E+00 vol/hr	reasonable assumption
Confined volume aerosol concentration		1.00E+02 mg/m3	reasonable assumption
Aerosol release rate from confined volume		1.43E-07 L/s	
Aerosol release from 1 hr confined volume release		5.14E-04 L	6.00E+01 minutes
Aerosol release from 24 hr confined volume release		1.23E-02 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak 1 hr aerosol release rate		1.57E-07 L/s	
Peak 24 hr aerosol release rate		1.75E-06 L/s	
Total 1 hr aerosol release		5.64E-04 L	
Total 24 hr aerosol release		1.51E-01 L	

95/5 DST Waste 20 gpm Leak

One hour leak quantity =	1,200 gal	Total time	2 40E+01 hours
24 hour leak quantity =	28,800 gal		1.44E+03 minutes
Transfer Line Length =	75,000 ft	14.2 miles	12 hr for X/Q
	Line vol.	28801 gallons	

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)
Inhalation	1.87E-04	1.66E-06
Ingestion	NA	1.38E-08
Gamma-ray	6.59E-04	NA
Total	8.46E-04	1.67E-06
Anticipated Guideline	5.00E-03	1.00E-03

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	1.63E-03		3.06E-05	
Guideline	1.00E+00		1.00E+00	

File:TWR3738Rev1/3738R1DST95

Inhalation Dose-Ratio of SC Release to Wind Entrainment			
Onsite Receptor,1hour		470.5	
Offsite Receptor, 24 hr		1.3	

95/5 DST Waste 20 gpm Leak
Summary of Results   Pipe Length (feet)   75,000.0

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*
Radiological	Onsite	8.46E-04	5.00E-03	5.10E-03
	Offsite	1.67E-06	1.00E-03	6.60E-06
Toxicological	Onsite	1.63E-03	1.00E+00	1.40E-01
	Offsite	3.06E-05	1.00E+00	7.50E-04

File:TWR3738Rev1/3738R1DST95

Radiological Consequences							
	Source Terms by Mechanism(L)						
	SupCover	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		4.92E-05		7.57E-04	3.30E-04	3.23E+04	3.97E-07
	5.14E-04			3.41E-02	3.30E-04	3.23E+04	1.87E-04
Gamma*			6.59E-04				6.59E-04
Total							8.46E-04
Offsite Inhalation		1.39E-01	NA	4.92E-07	3.30E-04	3.23E+04	7.29E-07
	1.23E-02		NA	7.07E-06	3.30E-04	3.23E+04	9.29E-07
Ingestion		1.39E-01		4.92E-07		8.86E-02	6.06E-09
	1.23E-02			7.07E-06		8.86E-02	7.73E-09
Total							1.67E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	SupCover	WetResus	SupCover	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.43E-07	1.37E-08			1.57E-07	1.04E+04	1.63E-03
Offsite	1.43E-07	1.37E-08	1.43E-07	1.61E-06	1.75E-06	1.75E+01	3.06E-05

File:TWR3738Rev1/3738R1DST95

67/33 SST Waste 20 gpm Leak

File:TWR3738Rev1/3738R1SST67

SST Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s L)
SST Liquids	1.1E+04	5.2E-02
SST Solids	2.2E+05	4.1E+00
67/33 Composite	8.0E+04	1.4E+00

SST Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
SST Liquids	9.6E+03	8.0E+00	7.5E+02	8.0E+00	2.0E+02	6.2E-01
SST Solids	4.0E+04	9.4E+01	2.1E+04	3.3E+01	1.0E+03	1.7E+01
67/33 Composite	2.0E+04	3.6E+01	7.4E+03	1.6E+01	4.6E+02	6.2E+00

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	7.07E-06

Breathing Rates (m3/s)

light activity	3.3E-04
24-hr average	3.3E-04

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	4.77E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	8.08E-01

Logarithmic Interpolated X/Q   2.12E-05

Time (hr)=	12	1.24E-07
X/Q =	7.07E-06	

67/33 SST Waste 20 gpm Leak

Pipe Length (feet)   75,000.0
File:TWR3738Rev1/3738R1SST67

Source Term

Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm		given
Time for leak detector alarm	0.00E+00 min		given
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	6.00E+02 gal		
Drainback pipe length	7.50E+04 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	2.88E+04 gal		
Drainback leak rate	2.00E+01 gpm		
Total spill volume in 24hours	2.88E+04 gal	1.09E+05 L	
Total spill duration(max=24hr)	1.44E+03 min	8.64E+04 s	2.40E+01 hr
Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	1.20E+03 gal	4.54E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	1.40E+03 ft2	1.30E+02 m2	
Pool radius	2.11E+01 ft	6.43E+00 m	
Wet resuspension flux		1.47E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.37E-08 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		4.92E-05 L	onsite evac. control
Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	2.88E+04 gal	1.09E+02 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	3.35E+04 ft2	3.12E+03 m2	
Pool radius	1.03E+02 ft	3.15E+01 m	
Wet resuspension flux		7.22E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.61E-06 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		1.39E-01 L	Leakage containment
Release from Supplementary Cover			& removal control
Confined volume	4.23E+01 ft3	1.20E+00 m3/vol	limiting assumption
Confined volume exchange rate		6.00E+00 vol/hr	reasonable assumption
Confined volume aerosol concentration		1.00E+02 mg/m3	reasonable assumption
Aerosol release rate from confined volume		1.43E-07 L/s	
Aerosol release from 1 hr confined volume release		5.14E-04 L	6.00E+01 minutes
Aerosol release from 24 hr confined volume release		1.23E-02 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak 1 hr aerosol release rate		1.57E-07 L/s	
Peak 24 hr aerosol release rate		1.75E-06 L/s	
Total 1 hr aerosol release		5.64E-04 L	
Total 24 hr aerosol release		1.51E-01 L	

67/33 SST Waste 20 gpm Leak

One hour leak quantity =		1,200	gal	Total time	2.40E+01 hours	
24 hour leak quantity =		28,800	gal		1.44E+03 minutes	
Transfer Line Length =		75,000	ft	14.2	miles	12 hr for X/Q
			Line vol.	28801	gallons	

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)
Inhalation	4.64E-04	4.11E-06
Ingestion	NA	2.16E-07
Gamma-ray	5.33E-04	NA
Total	9.97E-04	4.32E-06
Anticipated Guideline	5.00E-03	1.00E-03

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	3.07E-03		6.37E-05	
Guideline	1.00E+00		1.00E+00	

File:TWR3738Rev1/3738R1SST67

Inhalation Dose-Ratio of SC Release to Wind Entrainment			
Onsite Receptor,1hour		470.5	
Offsite Receptor, 24 hr		1.3	

67/33 SST Waste 20 gpm Leak
Summary of Results   Pipe Length (feet)   75,000.0

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*
Radiological	Onsite	9.97E-04	5.00E-03	5.10E-03
	Offsite	4.32E-06	1.00E-03	6.60E-06
Toxicological	Onsite	3.07E-03	1.00E+00	1.40E-01
	Offsite	6.37E-05	1.00E+00	7.50E-04

File:TWR3738Rev1/3738R1SST67

Radiological Consequences							
	Source Terms by Mechanism(L)						
	SupCover	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		4.92E-05		7.57E-04	3.30E-04	8.00E+04	9.84E-07
	5.14E-04			3.41E-02	3.30E-04	8.00E+04	4.63E-04
Gamma*			5.33E-04				5.33E-04
Total							9.97E-04
Offsite Inhalation		1.39E-01	NA	4.92E-07	3.30E-04	8.00E+04	1.80E-06
	1.23E-02		NA	7.07E-06	3.30E-04	8.00E+04	2.30E-06
Ingestion		1.39E-01		4.92E-07		1.39E+00	9.49E-08
	1.23E-02			7.07E-06		1.39E+00	1.21E-07
Total							4.32E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	SupCover	WetResus	SupCover	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.43E-07	1.37E-08			1.57E-07	1.96E+04	3.07E-03
Offsite	1.43E-07	1.37E-08	1.43E-07	1.61E-06	1.75E-06	3.64E+01	6.37E-05

File:TWR3738Rev1/3738R1SST67

95/5 SST Waste 20 gpm Leak

File:TWR3738Rev1/3738R1SST95

SST Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s L)
SST Liquids	1.1E+04	5.2E-02
SST Solids	2.2E+05	4.1E+00
95/5 Composite	2.1E+04	2.5E-01

SST Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
SST Liquids	9.6E+03	8.0E+00	7.5E+02	8.0E+00	2.0E+02	6.2E-01
SST Solids	4.0E+04	9.4E+01	2.1E+04	3.3E+01	1.0E+03	1.7E+01
95/5 Composite	1.1E+04	1.2E+01	1.8E+03	9.3E+00	2.4E+02	1.4E+00

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	7.07E-06

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	2.59E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	4.39E-01

Breathing Rates (m3/s)

light activity	3.3E-04
24-hr average	3.3E-04

Logarithmic Interpolated X/Q   2.12E-05

Time (hr)=	12	1.24E-07
X/Q =	7.07E-06	

95/5 SST Waste 20 gpm Leak

Pipe Length (feet)   75,000.0
File:TWR3738Rev1/3738R1SST95

Source Term

Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm		given
Time for leak detector alarm	0.00E+00 min		given
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	6.00E+02 gal		
Drainback pipe length	7.50E+04 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	2.88E+04 gal		
Drainback leak rate	2.00E+01 gpm		
Total spill volume in 24hours	2.88E+04 gal	1.09E+05 L	
Total spill duration(max=24hr)	1.44E+03 min	8.64E+04 s	2.40E+01 hr
Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	1.20E+03 gal	4.54E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	1.40E+03 ft2	1.30E+02 m2	
Pool radius	2.11E+01 ft	6.43E+00 m	
Wet resuspension flux		1.47E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.37E-08 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		4.92E-05 L	onsite evac. control
Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	2.88E+04 gal	1.09E+02 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	3.35E+04 ft2	3.12E+03 m2	
Pool radius	1.03E+02 ft	3.15E+01 m	
Wet resuspension flux		7.22E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.61E-06 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		1.39E-01 L	Leakage containment
Release from Supplementary Cover			& removal control
Confined volume	4.23E+01 ft3	1.20E+00 m3/vol	limiting assumption
Confined volume exchange rate		6.00E+00 vol/hr	reasonable assumption
Confined volume aerosol concentration		1.00E+02 mg/m3	reasonable assumption
Aerosol release rate from confined volume		1.43E-07 L/s	
Aerosol release from 1 hr confined volume release		5.14E-04 L	6.00E+01 minutes
Aerosol release from 24 hr confined volume release		1.23E-02 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak 1 hr aerosol release rate		1.57E-07 L/s	
Peak 24 hr aerosol release rate		1.75E-06 L/s	
Total 1 hr aerosol release		5.64E-04 L	
Total 24 hr aerosol release		1.51E-01 L	

95/5 SST Waste 20 gpm Leak

One hour leak quantity =	1,200 gal	Total time	2.40E+01 hours	
24 hour leak quantity =	28,800 gal		1.44E+03 minutes	
Transfer Line Length =	75,000 ft	14.2 miles		12 hr for X/Q
	Line vol.	28801 gallons		

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)
Inhalation	1.24E-04	1.10E-06
Ingestion	NA	3.96E-08
Gamma-ray	2.89E-04	NA
Total	4.14E-04	1.14E-06
Anticipated Guideline	5.00E-03	1.00E-03

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	1.74E-03		2.15E-05	
Guideline	1.00E+00		1.00E+00	

File:TWR3738Rev1/3738R1SST95

Inhalation Dose-Ratio of SC Release to Wind Entrainment			
Onsite Receptor,1hour		470.5	
Offsite Receptor, 24 hr		1.3	

95/5 SST Waste 20 gpm Leak
Summary of Results   Pipe Length (feet)   75,000.0

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*
Radiological	Onsite	4.14E-04	5.00E-03	5.10E-03
	Offsite	1.14E-06	1.00E-03	6.60E-06
Toxicological	Onsite	1.74E-03	1.00E+00	1.40E-01
	Offsite	2.15E-05	1.00E+00	7.50E-04

File:TWR3738Rev1/3738R1SST95

Radiological Consequences							
	Source Terms by Mechanism(L)						
	SupCover	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		4.92E-05		7.57E-04	3.30E-04	2.15E+04	2.64E-07
	5.14E-04			3.41E-02	3.30E-04	2.15E+04	1.24E-04
Gamma*			2.89E-04				2.89E-04
Total							4.14E-04
Offsite Inhalation		1.39E-01	NA	4.92E-07	3.30E-04	2.15E+04	4.84E-07
	1.23E-02		NA	7.07E-06	3.30E-04	2.15E+04	6.17E-07
Ingestion		1.39E-01		4.92E-07		2.54E-01	1.74E-08
	1.23E-02			7.07E-06		2.54E-01	2.22E-08
Total							1.14E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences						
	Initial Rates (L/s)		24 hour Rates (L/s)			
Location	SupCover	WetResus	SupCover	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.43E-07	1.37E-08			1.57E-07	1.11E+04	1.74E-03
Offsite	1.43E-07	1.37E-08	1.43E-07	1.61E-06	1.75E-06	1.23E+01	2.15E-05

File:TWR3738Rev1/3738R1SST95

67/33 AWF Waste and 20 gpm Leak

File:TWR3738Rev1/3738R1AWF67

AWF Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s L)
AWF Liquids	1.4E+03	9.2E-02
AWF Solids	1.7E+06	8.1E+00
67/33 Composite	5.6E+05	2.7E+00

AWF Continuous Release SOF Multipliers (s/L) (same as DST)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
AWF Liquids	1.0E+04	8.4E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
AWF Solids	1.8E+04	1.9E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
67/33 Composite	1.3E+04	6.8E+01	1.6E+03	1.1E+01	3.5E+02	1.3E+00

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	7.07E-06

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	9.13E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.55E+00

Breathing Rates (m3/s)

light activity	3.3E-04
24-hr average	3.3E-04	Note LA rate

Logarithmic Interpolated X/Q   2.12E-05

Time (hr)=   12   1.24E-07

X/Q =   7.07E-06

67/33 AWF Waste and 20 gpm Leak

Pipe Length (feet)   75,000.0

File:TWR3738Rev1/3738R1AWF67

Source Term

Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm		given
Time for leak detector alarm	0.00E+00 min		given
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	6.00E+02 gal		
Drainback pipe length	7.50E+04 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	2.88E+04 gal		
Drainback leak rate	2.00E+01 gpm		
Total spill volume in 24hours	2.88E+04 gal	1.09E+05 L	
Total spill duration(max=24hr)	1.44E+03 min	8.64E+04 s	2.40E+01 hr
Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	1.20E+03 gal	4.54E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	1.40E+03 ft2	1.30E+02 m2	
Pool radius	2.11E+01 ft	6.43E+00 m	
Wet resuspension flux		1.47E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.37E-08 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		4.92E-05 L	onsite evac. control
Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	2.88E+04 gal	1.09E+02 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	3.35E+04 ft2	3.12E+03 m2	
Pool radius	1.03E+02 ft	3.15E+01 m	
Wet resuspension flux		7.22E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.61E-06 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		1.39E-01 L	Leakage containment
Release from Supplementary Cover			& removal control
Confined volume	4.23E+01 ft3	1.20E+00 m3/vol	limiting assumption
Confined volume exchange rate		6.00E+00 vol/hr	reasonable assumption
Confined volume aerosol concentration		1.00E+02 mg/m3	reasonable assumption
Aerosol release rate from confined volume		1.43E-07 L/s	
Aerosol release from 1 hr confined volume release		5.14E-04 L	6.00E+01 minutes
Aerosol release from 24 hr confined volume release		1.23E-02 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak 1 hr aerosol release rate		1.57E-07 L/s	
Peak 24 hr aerosol release rate		1.75E-06 L/s	
Total 1 hr aerosol release		5.64E-04 L	
Total 24 hr aerosol release		1.51E-01 L	

67/33 AWF Waste and 20 gpm Leak

One hour leak quantity =   1,200 gal   Total time   2.40E+01 hours
24 hour leak quantity =   28,800 gal   1.44E+03 minutes
Transfer Line Length =   75,000 ft   14.2 miles   12 hr for X/Q
                                        Line vol.   28801 gallons

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)
Inhalation	3.26E-03	2.88E-05
Ingestion	NA	4.25E-07
Gamma-ray	1.02E-03	NA
Total	4.28E-03	2.93E-05
Anticipated Guideline	5.00E-03	1.00E-03

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	1.98E-03		1.20E-04	
Guideline	1.00E+00		1.00E+00	

File:TWR3738Rev1/3738R1AWF67

67/33 AWF Waste and 20 gpm Leak
Summary of Results   Pipe Length (feet)   75,000.0

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*
Radiological	Onsite	4.3E-03	5.0E-03	5.1E-03
	Offsite	2.9E-05	1.0E-03	6.6E-06
Toxicological	Onsite	2.0E-03	1.0E+00	1.4E-01
	Offsite	1.2E-04	1.0E+00	7.5E-04

File:TWR3738Rev1/3738R1AWF67

Radiological Consequences							
	Source Terms by Mechanism(L)						
	SupCover	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		4.92E-05		7.57E-04	3.30E-04	5.62E+05	6.91E-06
	5.14E-04			3.41E-02	3.30E-04	5.62E+05	3.25E-03
Gamma*			1.02E-03				1.02E-03
Total							4.28E-03
Offsite Inhalation		1.39E-01	NA	4.92E-07	3.30E-04	5.62E+05	1.27E-05
	1.23E-02		NA	7.07E-06	3.30E-04	5.62E+05	1.62E-05
Ingestion		1.39E-01		4.92E-07		2.73E+00	1.87E-07
	1.23E-02			7.07E-06		2.73E+00	2.39E-07
Total							2.93E-05

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	SupCover	WetResus	SupCover	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.43E-07	1.37E-08			1.57E-07	1.26E+04	1.98E-03
Offsite	1.43E-07	1.37E-08	1.43E-07	1.61E-06	1.75E-06	6.83E+01	1.20E-04

File:TWR3738Rev1/3738R1AWF67

67/33 DST Waste 20 gpm Leak

File:TWR3738Rev1/3738R1DST67

DST Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s L)
DST Liquids	6.1E+03	6.8E-02
DST Solids	5.3E+05	4.8E-01
67/33 Composite	1.8E+05	2.0E-01

DST Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
DST Liquids	1.0E+04	8.4E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
DST Solids	1.8E+04	1.9E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
67/33 Composite	1.3E+04	6.8E+01	1.6E+03	1.1E+01	3.5E+02	1.3E+00

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	7.07E-06

Breathing Rates (m3/s)

light activity	3.3E-04
24-hr average	3.3E-04

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	5.90E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.00E+00

Logarithmic Interpolated X/Q   2.12E-05

Time (hr)=   12   1.24E-07

X/Q =   7.07E-06

67/33 DST Waste 20 gpm Leak

Pipe Length (feet)   75,000.0

File:TWR3738Rev1/3738R1DST67

Source Term

Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm		given
Time for leak detector alarm	0.00E+00 min		given
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	6.00E+02 gal		
Drainback pipe length	7.50E+04 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	2.88E+04 gal		
Drainback leak rate	2.00E+01 gpm		
Total spill volume in 24hours	2.88E+04 gal	1.09E+05 L	
Total spill duration(max=24hr)	1.44E+03 min	8.64E+04 s	2.40E+01 hr
Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	1.20E+03 gal	4.54E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	1.40E+03 ft2	1.30E+02 m2	
Pool radius	2.11E+01 ft	6.43E+00 m	
Wet resuspension flux		1.47E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.37E-08 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		4.92E-05 L	onsite evac. control
Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	2.88E+04 gal	1.09E+02 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	3.35E+04 ft2	3.12E+03 m2	
Pool radius	1.03E+02 ft	3.15E+01 m	
Wet resuspension flux		7.22E-10 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		1.61E-06 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		1.39E-01 L	Leakage containment
Release from Supplementary Cover			& removal control
Confined volume	4.23E+01 ft3	1.20E+00 m3/vol	limiting assumption
Confined volume exchange rate		6.00E+00 vol/hr	reasonable assumptio
Confined volume aerosol concentration		1.00E+02 mg/m3	reasonable assumptio
Aerosol release rate from confined volume		1.43E-07 L/s	
Aerosol release from 1 hr confined volume release		5.14E-04 L	6.00E+01 minutes
Aerosol release from 24 hr confined volume release		1.23E-02 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak 1 hr aerosol release rate		1.57E-07 L/s	
Peak 24 hr aerosol release rate		1.75E-06 L/s	
Total 1 hr aerosol release		5.64E-04 L	
Total 24 hr aerosol release		1.51E-01 L	

67/33 DST Waste 20 gpm Leak

One hour leak quantity =   1,200 gal   Total time 2.40E+01 hours

24 hour leak quantity =   28,800 gal   1.44E+03 minutes

Transfer Line Length =   75,000 ft   14.2 miles   12 hr for X/Q

                                       Line vol.   28801 gallons

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)
Inhalation	1.04E-03	9.19E-06
Ingestion	NA	3.17E-08
Gamma-ray	6.59E-04	NA
Total	1.70E-03	9.22E-06
Anticipated Guid	5.00E-03	1.00E-03

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	1.98E-03		1.20E-04	
Guideline	1.00E+00		1.00E+00	

File:TWR3738Rev1/3738R1DST67

67/33 DST Waste 20 gpm Leak
Summary of Results   Pipe Length (feet)   75,000.0

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*
Radiological	Onsite	1.70E-03	5.00E-03	5.10E-03
	Offsite	9.22E-06	1.00E-03	6.60E-06
Toxicological	Onsite	1.98E-03	1.00E+00	1.40E-01
	Offsite	1.20E-04	1.00E+00	7.50E-04

File:TWR3738Rev1/3738R1DST67

Radiological Consequences							
	Source Terms by Mechanism(L)						
	SupCover	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite	Inhalation	4.92E-05		7.57E-04	3.30E-04	1.79E+05	2.20E-06
	5.14E-04			3.41E-02	3.30E-04	1.79E+05	1.04E-03
	Gamma*		6.59E-04				6.59E-04
	Total						1.70E-03
Offsite	Inhalation	1.39E-01	NA	4.92E-07	3.30E-04	1.79E+05	4.04E-06
	1.23E-02		NA	7.07E-06	3.30E-04	1.79E+05	5.15E-06
	Ingestion	1.39E-01		4.92E-07		2.04E-01	1.39E-08
	1.23E-02			7.07E-06		2.04E-01	1.78E-08
	Total						9.22E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	SupCover	WetResus	SupCover	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.43E-07	1.37E-08			1.57E-07	1.26E+04	1.98E-03
Offsite	1.43E-07	1.37E-08	1.43E-07	1.61E-06	1.75E-06	6.83E+01	1.20E-04

File:TWR3738Rev1/3738R1DST67

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67/33 AWF Waste/20 gpm Leak for Limiting Pit Size-HNF5147

File:TWR3738Rev1/PIT3738R1C

Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s-L)
AWF Liquids	1.400E+03	9.200E-02
AWF Solids	1.700E+06	8.100E+00
67/33 Composite	5.619E+05	2.735E+00

Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
AWF Liquids	1.000E+04	8.400E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
AWF Solids	1.800E+04	1.900E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
67/33 Composite	1.264E+04	6.833E+01	1.6E+03	1.1E+01	3.5E+02	1.3E+00

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	2.83E-05
	For 1 hour	For 1 hour

Breathing Rates (m3/s)

light activity	3.3E-04	
24-hr average	3.3E-04	Note LA rate

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	9.13E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.55E+00

67/33 AWF Waste/20 gpm Leak for Limiting Pit Size-HNF5147

Pipe Length (feet)   0.0   Pit Vol.   3.20E+03 feet³

File:TWR3738Rev1/PIT3738R1C   90.6 m³

Source Term			
Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm	7.57E+01 L/min	given
Time for leak detector alarm	3.00E+01 min		Input parameter
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Drainback pipe length	0.00E+00 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	0.00E+00 gal		
Drainback leak rate	2.00E+01 gpm	7.57E+01 L/min	
Total spill volume in 24hours	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Total spill duration(max=24hr)	6.00E+01 min	3.60E+03 s	1.00E+00 hr
NO Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		0.00E+00 L	onsite evac. control
NO Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		0.00E+00 L	Leakage containment
Release from Pit			& removal control
Pit internal volume	3.20E+03 ft3	9.06E+01 m3	Input parameter
Confined volume aerosol concentration		7.14E-05 L/m3	
Confined volume aerosol concentration		1.00E-01 g/m3	Quasi-equilibrium Concen-
Aerosol release rate from confined volume		1.80E-06 L/s	tration(PNL-4154)
Onsite aerosol release from pit		6.47E-03 L	6.00E+01 minutes
Pit aerosol release in 24 hr		6.47E-03 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak Onsite aerosol release rate from pit		1.80E-06 L/s	
Peak 24 hr release rate (pit)		1.80E-06 L/s	
Total Onsite aerosol release		6.47E-03 L	
Total 24 hr aerosol release		6.47E-03 L	

67/33 AWF Waste/20 gpm Leak for Limiting Pit Size-HNF5147

Pumped leak quantity =   1,200 gal   Total time 1.00E+00 hours
24 hour leak quantity =   1,200 gal   6.00E+01 minutes
Transfer Line Length =   0 ft   0.0 miles   1 hr for X/Q
Valve pit volume =   90.6 m^3

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)
Inhalation	4.09E-02	3.40E-05
Ingestion	NA	5.01E-07
Gamma-ray	0.00E+00	NA
Total	4.09E-02	3.45E-05
Anticipated Guideline	5.00E-03	1.00E-03

Toxicological Consequences

Pathway	Onsite MEI (SOF)	Offsite MEI (SOF)
Inhalation	2.27E-02	1.23E-04
Guideline	1.00E+00	1.00E+00

File:TWR3738Rev1/PIT3738R1C

67/33 AWF Waste/20 gpm Leak for Limiting Pit Size-HNF5147

Summary of Results   Pit Volume (ft3)   3.20E+03

m³   90.6

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*	HNF-5147
Radiological	Onsite	4.1E-02	5.0E-03	5.1E-03	4.1E-02
	Offsite	3.4E-05	1.0E-03	6.6E-06	3.7E-05
Toxicological	Onsite	2.3E-02	1.0E+00	1.4E-01	
	Offsite	1.2E-04	1.0E+00	7.5E-04	

File:TWR3738Rev1/PIT3738R1C

Radiological Consequences							
	Source Terms by Mechanism(L)						
	Pit	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		0.00E+00		7.57E-04	3.30E-04	5.62E+05	0.00E+00
	6.47E-03			3.41E-02	3.30E-04	5.62E+05	4.09E-02
Gamma*			0.00E+00				0.00E+00
Onsite Total							4.09E-02
Offsite Inhalation		0.00E+00	NA	4.92E-07	3.30E-04	5.62E+05	0.00E+00
	6.47E-03		NA	2.83E-05	3.30E-04	5.62E+05	3.40E-05
Ingestion		0.00E+00		4.92E-07		2.73E+00	0.00E+00
	6.47E-03			2.83E-05		2.73E+00	5.01E-07
Offsite Total							3.45E-05

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	Pit	WetResus	Pit	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.80E-06	0.00E+00			1.80E-06	1.26E+04	2.27E-02
Offsite	1.80E-06	0.00E+00	1.80E-06	0.00E+00	1.80E-06	6.83E+01	1.23E-04

File:TWR3738Rev1/PIT3738R1C

95/5 AWF Waste/20 gpm Leak for Limiting Pit Size-HNF5147

File:TWR3738Rev1/PIT3738R1C

Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s-L)
AWF Liquids	1.400E+03	9.200E-02
AWF Solids	1.700E+06	8.100E+00
95/5 Composite	8.633E+04	4.924E-01

Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
AWF Liquids	1.000E+04	8.400E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
AWF Solids	1.800E+04	1.900E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
95/5 Composite	1.040E+04	1.748E+01	8.8E+02	8.7E+00	2.3E+02	7.3E-01

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	2.83E-05
	For 1 hour	For 1 hour

Breathing Rates (m3/s)

light activity	3.3E-04	
24-hr average	3.3E-04	Note LA rate

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	8.85E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.50E+00

95/5 AWF Waste/20 gpm Leak for Limiting Pit Size-HNF5147

| Pipe Length (feet) | 0.0 | Pit Vol. | 1.39E+04 feet³ |
| File:TWR3738Rev1/PIT3738R1C | | | 392.6 m³ |

Source Term			
Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm	7.57E+01 L/min	given
Time for leak detector alarm	3.00E+01 min		Input parameter
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Drainback pipe length	0.00E+00 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	0.00E+00 gal		
Drainback leak rate	2.00E+01 gpm	7.57E+01 L/min	
Total spill volume in 24hours	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Total spill duration(max=24hr)	6.00E+01 min	3.60E+03 s	1.00E+00 hr
NO Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		0.00E+00 L	onsite evac. control
NO Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		0.00E+00 L	Leakage containment
Release from Pit			& removal control
Pit internal volume	1.39E+04 ft3	3.93E+02 m3	Input parameter
Confined volume aerosol concentration		7.14E-05 L/m3	
Confined volume aerosol concentration		1.00E-01 g/m3	*Quasi-equilibrium Concen-*
Aerosol release rate from confined volume		7.79E-06 L/s	*tration(PNL-4154)*
Onsite aerosol release from pit		2.80E-02 L	6.00E+01 minutes
Pit aerosol release in 24 hr		2.80E-02 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak Onsite aerosol release rate from pit		7.79E-06 L/s	
Peak 24 hr release rate (pit)		7.79E-06 L/s	
Total Onsite aerosol release		2.80E-02 L	
Total 24 hr aerosol release		2.80E-02 L	

95/5 AWF Waste/20 gpm Leak for Limiting Pit Size-HNF5147

Pumped leak quantity =   1,200 gal   Total time   1.00E+00 hours

24 hour leak quantity =   1,200 gal   6.00E+01 minutes

Transfer Line Length =   0 ft   0.0 miles   1 hr for X/Q

Valve pit volume =   392.6 m^3

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)		Offsite MEI EDE (Sv)	
Inhalation	2.72E-02		2.26E-05	
Ingestion	NA		3.91E-07	
Gamma-ray	0.00E+00		NA	
Total	2.72E-02		2.30E-05	
Anticipated Guideline	5.00E-03		1.00E-03	

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	8.10E-02		1.36E-04	
Guideline	1.00E+00		1.00E+00	

File:TWR3738Rev1/PIT3738R1C

95/5 AWF Waste/20 gpm Leak for Limiting Pit Size-HNF5147

Summary of Results Pit Volume (ft3) 1.39E+04

m^3 392.6

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*	FSAR**
Radiological	Onsite	2.7E-02	5.0E-03	5.1E-03	1.8E-03
	Offsite	2.3E-05	1.0E-03	6.6E-06	1.0E-06
Toxicological	Onsite	8.1E-02	1.0E+00	1.4E-01	
	Offsite	1.4E-04	1.0E+00	7.5E-04	

File:TWR3738Rev1/PIT3738R1C

Radiological Consequences							
	Source Terms by Mechanism(L)						
	Pit	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		0.00E+00		7.57E-04	3.30E-04	8.63E+04	0.00E+00
	2.80E-02			3.41E-02	3.30E-04	8.63E+04	2.72E-02
Gamma*			0.00E+00				0.00E+00
Onsite Total							2.72E-02
Offsite Inhalation		0.00E+00	NA	4.92E-07	3.30E-04	8.63E+04	0.00E+00
	2.80E-02		NA	2.83E-05	3.30E-04	8.63E+04	2.26E-05
Ingestion		0.00E+00		4.92E-07		4.92E-01	0.00E+00
	2.80E-02			2.83E-05		4.92E-01	3.91E-07
Offsite Total							2.30E-05

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	Pit	WetResus	Pit	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	7.79E-06	0.00E+00			7.79E-06	1.04E+04	8.10E-02
Offsite	7.79E-06	0.00E+00	7.79E-06	0.00E+00	7.79E-06	1.75E+01	1.36E-04

File:TWR3738Rev1/PIT3738R1C

67/33 AWF Waste/20 gpm Leak for Limiting Pit Size

File:TWR3738Rev1/PIT3738R1C

Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s-L)
AWF Liquids	1.400E+03	9.200E-02
AWF Solids	1.700E+06	8.100E+00
67/33 Composite	5.6E+05	2.7E+00

Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
AWF Liquids	1.000E+04	8.400E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
AWF Solids	1.800E+04	1.900E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
67/33 Composite	1.3E+04	6.8E+01	1.6E+03	1.1E+01	3.5E+02	1.5E+00

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	2.83E-05
	For 1 hour	For 1 hour

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	9.13E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.55E+00

Breathing Rates (m3/s)

light activity	3.3E-04	
24-hr average	3.3E-04	Note LA rate

67/33 AWF Waste/20 gpm Leak for Limiting Pit Size

Pipe Length (feet)	0.0	Pit Vol. 3.91E+02 feet^3
File:TWR3738Rev1/PIT3738R1C		11.08 m^3

Source Term			
Parameter	English Units	Metric Units	_Basis_
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm	7.57E+01 L/min	given
Time for leak detector alarm	3.00E+01 min		Input parameter
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Drainback pipe length	0.00E+00 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	0.00E+00 gal		
Drainback leak rate	2.00E+01 gpm	7.57E+01 L/min	
Total spill volume in 24hours	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Total spill duration(max=24hr)	6.00E+01 min	3.60E+03 s	1.00E+00 hr
NO Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		0.00E+00 L	onsite evac. control
NO Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		0.00E+00 L	Leakage containment
Release from Pit			& removal control
Pit internal volume	3.91E+02 ft3	1.11E+01 m3	Input parameter
Confined volume aerosol concentration		7.14E-05 L/m3	
Confined volume aerosol concentration		1.00E-01 g/m3	Quasi-equilibrium Concen-
Aerosol release rate from confined volume		2.20E-07 L/s	tration(PNL-4154)
Onsite aerosol release from pit		7.91E-04 L	6.00E+01 minutes
Pit aerosol release in 24 hr		7.91E-04 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak Onsite aerosol release rate from pit		2.20E-07 L/s	
Peak 24 hr release rate (pit)		2.20E-07 L/s	
Total Onsite aerosol release		7.91E-04 L	
Total 24 hr aerosol release		7.91E-04 L	

67/33 AWF Waste/20 gpm Leak for Limiting Pit Size

Pumped leak quantity =	1,200 gal	Total time	1.00E+00 hours	
24 hour leak quantity =	1,200 gal		6.00E+01 minutes	
Transfer Line Length =	0 ft	0.0 miles		1 hr for X/Q
Valve pit volume =	11.08 m^3			

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)		Offsite MEI EDE (Sv)	
Inhalation	5.00E-03		4.15E-06	
Ingestion	NA		6.12E-08	
Gamma-ray	0.00E+00		NA	
Total	5.00E-03		4.21E-06	
Anticipated Guideline	5.00E-03		1.00E-03	

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	2.78E-03		1.50E-05	
Guideline	1.00E+00		1.00E+00	

File:TWR3738Rev1/PIT3738R1C

67/33 AWF Waste/20 gpm Leak for Limiting Pit Size

Summary of Results Pit Volume (ft3) 3.91E+02

m^3 11.08

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*	HNF-5147
Radiological	Onsite	5.0E-03	5.0E-03	5.1E-03	4.1E-02
	Offsite	4.2E-06	1.0E-03	6.6E-06	3.7E-05
Toxicological	Onsite	2.8E-03	1.0E+00	1.4E-01	
	Offsite	1.5E-05	1.0E+00	7.5E-04	

File:TWR3738Rev1/PIT3738R1C

Radiological Consequences							
	Source Terms by Mechanism(L)						
	Pit	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		0.00E+00		7.57E-04	3.30E-04	5.62E+05	0.00E+00
	7.91E-04			3.41E-02	3.30E-04	5.62E+05	5.00E-03
Gamma*			0.00E+00				0.00E+00
Onsite Total							5.00E-03
Offsite Inhalation		0.00E+00	NA	4.92E-07	3.30E-04	5.62E+05	0.00E+00
	7.91E-04		NA	2.83E-05	3.30E-04	5.62E+05	4.15E-06
Ingestion		0.00E+00		4.92E-07		2.73E+00	0.00E+00
	7.91E-04			2.83E-05		2.73E+00	6.12E-08
Offsite Total							4.21E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	Pit	WetResus	Pit	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	2.20E-07	0.00E+00			2.20E-07	1.26E+04	2.78E-03
Offsite	2.20E-07	0.00E+00	2.20E-07	0.00E+00	2.20E-07	6.83E+01	1.50E-05

File:TWR3738Rev1/PIT3738R1C

95/5 AWF Waste/20 gpm Leak for Limiting Pit Size

File:TWR3738Rev1/PIT3738R1C

Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s-L)
AWF Liquids	1.400E+03	9.200E-02
AWF Solids	1.700E+06	8.100E+00
95/5 Composite	8.633E+04	4.924E-01

Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
AWF Liquids	1.000E+04	8.400E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
AWF Solids	1.800E+04	1.900E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
95/5 Composite	1.040E+04	1.748E+01	8.8E+02	8.7E+00	2.3E+02	7.3E-01

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	2.83E-05
	For 1 hour	For 1 hour

Breathing Rates (m3/s)

light activity	3.3E-04	
24-hr average	3.3E-04	Note LA rate

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	8.85E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.50E+00

95/5 AWF Waste/20 gpm Leak for Limiting Pit Size

| Pipe Length (feet) | 0.0 | Pit Vol. | 2.55E+03 feet³ |
| File:TWR3738Rev1/PIT3738R1C | | | 72.1 m³ |

Source Term			
Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm	7.57E+01 L/min	given
Time for leak detector alarm	3.00E+01 min		Input parameter
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Drainback pipe length	0.00E+00 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	0.00E+00 gal		
Drainback leak rate	2.00E+01 gpm	7.57E+01 L/min	
Total spill volume in 24hours	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Total spill duration(max=24hr)	6.00E+01 min	3.60E+03 s	1.00E+00 hr
NO Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		0.00E+00 L	onsite evac. control
NO Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		0.00E+00 L	Leakage containment
Release from Pit			& removal control
Pit internal volume	2.55E+03 ft3	7.21E+01 m3	Input parameter
Confined volume aerosol concentration		7.14E-05 L/m3	
Confined volume aerosol concentration		1.00E-01 g/m3	Quasi-equilibrium Concen-
Aerosol release rate from confined volume		1.43E-06 L/s	tration(PNL-4154)
Onsite aerosol release from pit		5.15E-03 L	6.00E+01 minutes
Pit aerosol release in 24 hr		5.15E-03 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak Onsite aerosol release rate from pit		1.43E-06 L/s	
Peak 24 hr release rate (pit)		1.43E-06 L/s	
Total Onsite aerosol release		5.15E-03 L	
Total 24 hr aerosol release		5.15E-03 L	

95/5 AWF Waste/20 gpm Leak for Limiting Pit Size

Pumped leak quantity =	1,200 gal	Total time	1.00E+00 hours
24 hour leak quantity =	1,200 gal		6.00E+01 minutes
Transfer Line Length =	0 ft	0.0 miles	1 hr for X/Q
Valve pit volume =	72.1 m^3		

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)
Inhalation	5.00E-03	4.15E-06
Ingestion	NA	7.18E-08
Gamma-ray	0.00E+00	NA
Total	5.00E-03	4.22E-06
Anticipated Guideline	5.00E-03	1.00E-03

Toxicological Consequences

Pathway	Onsite MEI (SOF)	Offsite MEI (SOF)
Inhalation	1.49E-02	2.50E-05
Guideline	1.00E+00	1.00E+00

File:TWR3738Rev1/PIT3738R1C

95/5 AWF Waste/20 gpm Leak for Limiting Pit Size
Summary of Results Pit Volume (ft3) 2.55E+03

m^3 72.1

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*	HNF-5147
Radiological	Onsite	5.0E-03	5.0E-03	5.1E-03	4.1E-02
	Offsite	4.2E-06	1.0E-03	6.6E-06	3.7E-05
Toxicological	Onsite	1.5E-02	1.0E+00	1.4E-01	
	Offsite	2.5E-05	1.0E+00	7.5E-04	

File:TWR3738Rev1/PIT3738R1C

Radiological Consequences							
	Source Terms by Mechanism(L)						
	Pit	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		0.00E+00		7.57E-04	3.30E-04	8.63E+04	0.00E+00
	5.15E-03			3.41E-02	3.30E-04	8.63E+04	5.00E-03
Gamma*			0.00E+00				0.00E+00
Onsite Total							5.00E-03
Offsite Inhalation		0.00E+00	NA	4.92E-07	3.30E-04	8.63E+04	0.00E+00
	5.15E-03		NA	2.83E-05	3.30E-04	8.63E+04	4.15E-06
Ingestion		0.00E+00		4.92E-07		4.92E-01	0.00E+00
	5.15E-03			2.83E-05		4.92E-01	7.18E-08
Offsite Total							4.22E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	Pit	WetResus	Pit	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.43E-06	0.00E+00			1.43E-06	1.04E+04	1.49E-02
Offsite	1.43E-06	0.00E+00	1.43E-06	0.00E+00	1.43E-06	1.75E+01	2.50E-05

File:TWR3738Rev1/PIT3738R1C

67/33 DST Waste/20 gpm Leak for Limiting Pit Size

File:TWR3738Rev1/PIT3738R1B

DST Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s L)
DST Liquids	6.1E+03	6.8E-02
DST Solids	5.3E+05	4.8E-01
67/33 Composite	1.8E+05	2.0E-01

DST Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
DST Liquids	1.0E+04	8.4E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
DST Solids	1.8E+04	1.9E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
67/33 Composite	1.3E+04	6.8E+01	1.6E+03	1.1E+01	3.5E+02	1.3E+00

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR	7.57E-04	4.92E-07
99.5%, 1m/s,TWR	3.41E-02	2.83E-05

For 1 hour For 1 hour

Breathing Rates (m3/s)

light activity	3.3E-04	
24-hr average	3.3E-04	Note LA rate

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	5.90E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.00E+00

67/33 DST Waste/20 gpm Leak for Limiting Pit Size

Pipe Length (feet)	0.0	Pit Vol.	1.24E+03 feet³
File:TWR3738Rev1/PIT3738R1B			35 m³

Source Term			
Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm	7.57E+01 L/min	given
Time for leak detector alarm	3.00E+01 min		Input parameter
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Drainback pipe length	0.00E+00 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	0.00E+00 gal		
Drainback leak rate	2.00E+01 gpm	7.57E+01 L/min	
Total spill volume in 24hours	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Total spill duration(max=24hr)	6.00E+01 min	3.60E+03 s	1.00E+00 hr
NO Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		0.00E+00 L	onsite evac. control
NO Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		0.00E+00 L	Leakage containment
Release from Pit			& removal control
Pit internal volume	1.24E+03 ft3	3.50E+01 m3	Input parameter
Confined volume aerosol concentration		7.14E-05 L/m3	
Confined volume aerosol concentration		1.00E-01 g/m3	Quasi-equilibrium Concen-
Aerosol release rate from confined volume		6.94E-07 L/s	tration(PNL-4154)
Onsite aerosol release from pit		2.50E-03 L	6.00E+01 minutes
Pit aerosol release in 24 hr		2.50E-03 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak Onsite aerosol release rate from pit		6.94E-07 L/s	
Peak 24 hr release rate (pit)		6.94E-07 L/s	
Total Onsite aerosol release		2.50E-03 L	
Total 24 hr aerosol release		2.50E-03 L	

67/33 DST Waste/20 gpm Leak for Limiting Pit Size

Pumped leak quantity =	1,200 gal	Total time	1.00E+00 hours	
24 hour leak quantity =	1,200 gal		6.00E+01 minutes	
Transfer Line Length =	0 ft	0.0 miles		1 hr for X/Q
Valve pit volume =	35 m^3			

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)	
Inhalation	5.04E-03	4.18E-06	
Ingestion	NA	1.44E-08	
Gamma-ray	0.00E+00	NA	
Total	5.04E-03	4.19E-06	
Anticipated Guidel	5.00E-03	1.00E-03	

Toxicological Consequences

Pathway	Onsite MEI (SOF)	Offsite MEI (SOF)	
Inhalation	8.78E-03	4.75E-05	
Guideline	1.00E+00	1.00E+00	

File:TWR3738Rev1/PIT3738R1B

67/33 DST Waste/20 gpm Leak for Limiting Pit Size

Summary of Results   Pit Volume (ft3)   1.24E+03

m^3 35

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*
Radiological	Onsite	5.0E-03	5.0E-03	5.1E-03
	Offsite	4.2E-06	1.0E-03	6.6E-06
Toxicological	Onsite	8.8E-03	1.0E+00	1.4E-01
	Offsite	4.7E-05	1.0E+00	7.5E-04

File:TWR3738Rev1/PIT3738R1B

Radiological Consequences							
	Source Terms by Mechanism(L)						
	Pit	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		0.00E+00		7.57E-04	3.30E-04	1.79E+05	0.00E+00
	2.50E-03			3.41E-02	3.30E-04	1.79E+05	5.04E-03
Gamma*		0.00E+00					0.00E+00
Onsite Total							5.04E-03
Offsite Inhalation		0.00E+00	NA	4.92E-07	3.30E-04	1.79E+05	0.00E+00
	2.50E-03		NA	2.83E-05	3.30E-04	1.79E+05	4.18E-06
Ingestion		0.00E+00		4.92E-07		2.04E-01	0.00E+00
	2.50E-03			2.83E-05		2.04E-01	1.44E-08
Offsite Total							4.19E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	Pit	WetResus	Pit	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	6.94E-07	0.00E+00			6.94E-07	1.26E+04	8.78E-03
Offsite	6.94E-07	0.00E+00	6.94E-07	0.00E+00	6.94E-07	6.83E+01	4.75E-05

File:TWR3738Rev1/PIT3738R1B

95/5 DST Waste/20 gpm Leak for Limiting Pit Size

File:TWR3738Rev1/PIT3738R1B

DST Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s L)
DST Liquids	6.1E+03	6.8E-02
DST Solids	5.3E+05	4.8E-01
95/5 Composite	3.2E+04	8.9E-02

DST Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
DST Liquids	1.0E+04	8.4E+00	7.5E+02	8.4E+00	2.1E+02	6.2E-01
DST Solids	1.8E+04	1.9E+02	3.3E+03	1.5E+01	6.3E+02	2.8E+00
95/5 Composite	1.0E+04	1.7E+01	8.8E+02	8.7E+00	2.3E+02	7.3E-01

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR	7.57E-04	4.92E-07
99.5%, 1m/s,TWR	3.41E-02	2.83E-05
	For 1 hour	For 1 hour

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	5.90E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	1.00E+00

Breathing Rates (m3/s)

light activity	3.3E-04	
24-hr average	3.3E-04	Note LA rate

95/5 DST Waste/20 gpm Leak for Limiting Pit Size

Pipe Length (feet)		0.0	Pit Vol.	6.71E+03 feet³
File:TWR3738Rev1/PIT3738R1B				190 m³

Source Term				
Parameter	**English Units**		**Metric Units**	**Basis**
Waste Density			1.40E+00 kg/L	Past BIO practice
Soil Density			1.6 kg/L	
Leak Evaluation				
Leak flow rate	2.00E+01 gpm		7.57E+01 L/min	given
Time for leak detector alarm	3.00E+01 min			Input parameter
Time to trfr pump shutdown	3.00E+01 min			given
Pumped spill volume	1.20E+03 gal		4.54E+03 L	4.54E+00 m3
Drainback pipe length	0.00E+00 ft			given
Pipe ID	3.07E+00 in			given
Drainback volume	0.00E+00 gal			
Drainback leak rate	2.00E+01 gpm		7.57E+01 L/min	
Total spill volume in 24hours	1.20E+03 gal		4.54E+03 L	4.54E+00 m3
Total spill duration(max=24hr)	6.00E+01 min		3.60E+03 s	1.00E+00 hr
NO Wind Entrainment to Onsite Receptor				
1 hr surface pool spill volume	0.00E+00 gal		0.00E+00 m3	
Spreading factor	8.70E+00 ft-1			Past BIO practice
Pool area	0.00E+00 ft2		0.00E+00 m2	
Pool radius	0.00E+00 ft		0.00E+00 m	
Wet resuspension flux			0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension			0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension			0.00E+00 L	onsite evac. control
NO Wind Entrainment to Offsite Receptor				
24 hr surface pool volume	0.00E+00 gal		0.00E+00 m3	
Spreading factor	8.70E+00 ft-1			Past BIO practice
Pool area	0.00E+00 ft2		0.00E+00 m2	
Pool radius	0.00E+00 ft		0.00E+00 m	
Wet resuspension flux			0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension			0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension			0.00E+00 L	Leakage containment
Release from Pit				& removal control
Pit internal volume	6.71E+03 ft3		1.90E+02 m3	Input parameter
Confined volume aerosol concentration			7.14E-05 L/m3	
Confined volume aerosol concentration			1.00E-01 g/m3	Quasi-equilibrium Concen-
Aerosol release rate from confined volume			3.77E-06 L/s	tration(PNL-4154)
Onsite aerosol release from pit			1.36E-02 L	6.00E+01 minutes
Pit aerosol release in 24 hr			1.36E-02 L	1.44E+03 minutes
Summary of Releases and Rates				
Peak Onsite aerosol release rate from pit			3.77E-06 L/s	
Peak 24 hr release rate (pit)			3.77E-06 L/s	
Total Onsite aerosol release			1.36E-02 L	
Total 24 hr aerosol release			1.36E-02 L	

95/5 DST Waste/20 gpm Leak for Limiting Pit Size

Pumped leak quantity = 1,200 gal   Total time   1.00E+00 hours
24 hour leak quantity = 1,200 gal   6.00E+01 minutes
Transfer Line Length = 0 ft   0.0 miles   1 hr for X/Q
Valve pit volume = 190 m^3

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)		Offsite MEI EDE (Sv)	
Inhalation	4.93E-03		4.09E-06	
Ingestion	NA		3.40E-08	
Gamma-ray	0.00E+00		NA	
Total	4.93E-03		4.13E-06	
Anticipated Guidel	5.00E-03		1.00E-03	

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	3.92E-02		6.59E-05	
Guideline	1.00E+00		1.00E+00	

File:TWR3738Rev1/PIT3738R1B

95/5 DST Waste/20 gpm Leak for Limiting Pit Size

Summary of Results   Pit Volume (ft3)   6.71E+03

                                 m³   190

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*
Radiological	Onsite	4.9E-03	5.0E-03	5.1E-03
	Offsite	4.1E-06	1.0E-03	6.6E-06
Toxicological	Onsite	3.9E-02	1.0E+00	1.4E-01
	Offsite	6.6E-05	1.0E+00	7.5E-04

File:TWR3738Rev1/PIT3738R1B

Radiological Consequences							
	Source Terms by Mechanism(L)						
	Pit	**WetResus**	**Gamma**	**X/Q(s/m3)**	**BR(m3/s)**	**ULD(Sv/L)**	**Dose(Sv)**
Onsite Inhalation		0.00E+00		7.57E-04	3.30E-04	3.23E+04	0.00E+00
	1.36E-02			3.41E-02	3.30E-04	3.23E+04	4.93E-03
Gamma*			0.00E+00				0.00E+00
Onsite Total							4.93E-03
Offsite Inhalation		0.00E+00	NA	4.92E-07	3.30E-04	3.23E+04	0.00E+00
	1.36E-02		NA	2.83E-05	3.30E-04	3.23E+04	4.09E-06
Ingestion		0.00E+00		4.92E-07		8.86E-02	0.00E+00
	1.36E-02			2.83E-05		8.86E-02	3.40E-08
Offsite Total							4.13E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		**24 hour Rates (L/s)**				
Location	**Pit**	**WetResus**	**Pit**	**WetResus**	**Rate (L/s)**	**SOF Mult**	**SOF**
Onsite	3.77E-06	0.00E+00			3.77E-06	1.04E+04	3.92E-02
Offsite	3.77E-06	0.00E+00	3.77E-06	0.00E+00	3.77E-06	1.75E+01	6.59E-05

File:TWR3738Rev1/PIT3738R1B

67/33 SST Waste/20 gpm Leak for Limiting Pit Size

File:TWR3738Rev1/PIT3738R1C

SST Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s-L)
SST Liquids	1.1E+04	5.2E-02
SST Solids	2.2E+05	4.1E+00
67/33 Composite	8.0E+04	1.4E+00

SST Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
SST Liquids	9.6E+03	8.0E+00	7.5E+02	8.0E+00	2.0E+02	6.2E-01
SST Solids	4.0E+04	9.4E+01	2.1E+04	3.3E+01	1.0E+03	1.7E+01
67/33 Composite	2.0E+04	3.6E+01	7.4E+03	1.6E+01	4.6E+02	6.2E+00

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR-3958	7.57E-04	4.92E-07
99.5%, 1m/s,TWR-3738	3.41E-02	2.83E-05
	For 1 hour	For 1 hour

Breathing Rates (m3/s)

light activity	3.3E-04	
24-hr average	3.3E-04	Note LA rate

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	4.77E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	8.08E-01

67/33 SST Waste/20 gpm Leak for Limiting Pit Size

Pipe Length (feet)		0.0	Pit Vol.	2.75E+03 feet³
File:TWR3738Rev1/PIT3738R1C				77.8 m³

Source Term			
Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm	7.57E+01 L/min	given
Time for leak detector alarm	3.00E+01 min		Input parameter
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Drainback pipe length	0.00E+00 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	0.00E+00 gal		
Drainback leak rate	2.00E+01 gpm	7.57E+01 L/min	
Total spill volume in 24hours	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Total spill duration(max=24hr)	6.00E+01 min	3.60E+03 s	1.00E+00 hr
NO Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		0.00E+00 L	onsite evac. control
NO Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		0.00E+00 L	Leakage containment
Release from Pit			& removal control
Pit internal volume	2.75E+03 ft3	7.78E+01 m3	Input parameter
Confined volume aerosol concentration		7.14E-05 L/m3	
Confined volume aerosol concentration		1.00E-01 g/m3	Quasi-equilibrium Concen-
Aerosol release rate from confined volume		1.54E-06 L/s	tration(PNL-4154)
Onsite aerosol release from pit		5.56E-03 L	6.00E+01 minutes
Pit aerosol release in 24 hr		5.56E-03 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak Onsite aerosol release rate from pit		1.54E-06 L/s	
Peak 24 hr release rate (pit)		1.54E-06 L/s	
Total Onsite aerosol release		5.56E-03 L	
Total 24 hr aerosol release		5.56E-03 L	

67/33 SST Waste/20 gpm Leak for Limiting Pit Size

Pumped leak quantity =	1,200 gal	Total time	1.00E+00 hours	
24 hour leak quantity =	1,200 gal		6.00E+01 minutes	
Transfer Line Length =	0 ft	0.0 miles		1 hr for X/Q
Valve pit volume =	77.8 m^3			

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)		Offsite MEI EDE (Sv)	
Inhalation	5.00E-03		4.15E-06	
Ingestion	NA		2.18E-07	
Gamma-ray	0.00E+00		NA	
Total	5.00E-03		4.37E-06	
Anticipated Guideline	5.00E-03		1.00E-03	

Toxicological Consequences

Pathway	Onsite MEI (SOF)		Offsite MEI (SOF)	
Inhalation	3.03E-02		5.62E-05	
Guideline	1.00E+00		1.00E+00	

File:TWR3738Rev1/PIT3738R1C

67/33 SST Waste/20 gpm Leak for Limiting Pit Size

Summary of Results		Pit Volume (ft3)		2.75E+03	
		m^3		77.8	

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*	HNF-5147
Radiological	Onsite	5.0E-03	5.0E-03	5.1E-03	4.1E-02
	Offsite	4.4E-06	1.0E-03	6.6E-06	3.7E-05
Toxicological	Onsite	3.0E-02	1.0E+00	1.4E-01	
	Offsite	5.6E-05	1.0E+00	7.5E-04	

File:TWR3738Rev1/PIT3738R1C

Radiological Consequences							
	Source Terms by Mechanism(L)						
	Pit	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		0.00E+00		7.57E-04	3.30E-04	8.00E+04	0.00E+00
	5.56E-03			3.41E-02	3.30E-04	8.00E+04	5.00E-03
Gamma*			0.00E+00				0.00E+00
Onsite Total							5.00E-03
Offsite Inhalation		0.00E+00	NA	4.92E-07	3.30E-04	8.00E+04	0.00E+00
	5.56E-03		NA	2.83E-05	3.30E-04	8.00E+04	4.15E-06
Ingestion		0.00E+00		4.92E-07		1.39E+00	0.00E+00
	5.56E-03			2.83E-05		1.39E+00	2.18E-07
Offsite Total							4.37E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		**24 hour Rates (L/s)**				
Location	Pit	WetResus	Pit	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	1.54E-06	0.00E+00			1.54E-06	1.96E+04	3.03E-02
Offsite	1.54E-06	0.00E+00	1.54E-06	0.00E+00	1.54E-06	3.64E+01	5.62E-05

File:TWR3738Rev1/PIT3738R1C

95/5 SST Waste/20 gpm Leak for Limiting Pit Size

File:TWR3738Rev1/PIT3738R1B

SST Radiological Unit Liter Doses

Waste Type	Inhalation (Sv/L)	Ingestion (Sv-m^3/s L)
SST Liquids	1.1E+04	5.2E-02
SST Solids	2.2E+05	4.1E+00
95/5 Composite	2.1E+04	2.5E-01

SST Continuous Release SOF Multipliers (s/L)

Waste Type	Anticipated Frequency		Unlikely Frequency		Extremely Unlikely Frequency	
	Onsite	Offsite	Onsite	Offsite	Onsite	Offsite
SST Liquids	9.6E+03	8.0E+00	7.5E+02	8.0E+00	2.0E+02	6.2E-01
SST Solids	4.0E+04	9.4E+01	2.1E+04	3.3E+01	1.0E+03	1.7E+01
95/5 Composite	1.1E+04	1.2E+01	1.8E+03	9.3E+00	2.4E+02	1.4E+00

Atmospheric Dispersion Coefficients (X/Q)

	Onsite	Offsite
95%, 9.8m/s,TWR	7.57E-04	4.92E-07
99.5%, 1m/s,TWR	3.41E-02	2.83E-05
	For 1 hour	For 1 hour

Waste Cs-137 Activity (Bq/L)

Cs-137 Activity for this waste	2.59E+10
Cs-137 Activity, Ref. DST 95/5	5.90E+10
Gamma Multiplier for this waste	4.39E-01

Breathing Rates (m3/s)

light activity	3.3E-04	
24-hr average	3.3E-04	Note LA rate

95/5 SST Waste/20 gpm Leak for Limiting Pit Size

Pipe Length (feet)	0.0	Pit Vol.	1.02E+04 feet^3
File:TWR3738Rev1/PIT3738R1B			290 m^3

Source Term			
Parameter	English Units	Metric Units	Basis
Waste Density		1.40E+00 kg/L	Past BIO practice
Soil Density		1.6 kg/L	
Leak Evaluation			
Leak flow rate	2.00E+01 gpm	7.57E+01 L/min	given
Time for leak detector alarm	3.00E+01 min		Input parameter
Time to trfr pump shutdown	3.00E+01 min		given
Pumped spill volume	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Drainback pipe length	0.00E+00 ft		given
Pipe ID	3.07E+00 in		given
Drainback volume	0.00E+00 gal		
Drainback leak rate	2.00E+01 gpm	7.57E+01 L/min	
Total spill volume in 24hours	1.20E+03 gal	4.54E+03 L	4.54E+00 m3
Total spill duration(max=24hr)	6.00E+01 min	3.60E+03 s	1.00E+00 hr
NO Wind Entrainment to Onsite Receptor			
1 hr surface pool spill volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 1 hr wet resuspension		0.00E+00 L	onsite evac. control
NO Wind Entrainment to Offsite Receptor			
24 hr surface pool volume	0.00E+00 gal	0.00E+00 m3	
Spreading factor	8.70E+00 ft-1		Past BIO practice
Pool area	0.00E+00 ft2	0.00E+00 m2	
Pool radius	0.00E+00 ft	0.00E+00 m	
Wet resuspension flux		0.00E+00 kg/m2-s	Based on TWR-3958
Aerosol release rate from wet resuspension		0.00E+00 L/s	eqn 4-1 & 9.8 m/sec
Aerosol released from 24 hr wet resuspension		0.00E+00 L	Leakage containment
Release from Pit			& removal control
Pit internal volume	1.02E+04 ft3	2.90E+02 m3	Input parameter
Confined volume aerosol concentration		7.14E-05 L/m3	
Confined volume aerosol concentration		1.00E-01 g/m3	Quasi-equilibrium Concen-
Aerosol release rate from confined volume		5.75E-06 L/s	tration(PNL-4154)
Onsite aerosol release from pit		2.07E-02 L	6.00E+01 minutes
Pit aerosol release in 24 hr		2.07E-02 L	1.44E+03 minutes
Summary of Releases and Rates			
Peak Onsite aerosol release rate from pit		5.75E-06 L/s	
Peak 24 hr release rate (pit)		5.75E-06 L/s	
Total Onsite aerosol release		2.07E-02 L	
Total 24 hr aerosol release		2.07E-02 L	

95/5 SST Waste/20 gpm Leak for Limiting Pit Size

Pumped leak quantity =   1,200 gal   Total time   1.00E+00 hours
24 hour leak quantity =   1,200 gal   6.00E+01 minutes
Transfer Line Length =   0 ft   0.0 miles   1 hr for X/Q
Valve pit volume (m^3) =   290   Line vol.   0 gallons

Radiological Consequences

Pathway	Onsite MEI EDE (Sv)	Offsite MEI EDE (Sv)
Inhalation	5.00E-03	4.15E-06
Ingestion	NA	1.49E-07
Gamma-ray	0.00E+00	NA
Total	5.00E-03	4.30E-06
Anticipated Guidel	5.00E-03	1.00E-03

Toxicological Consequences

Pathway	Onsite MEI (SOF)	Offsite MEI (SOF)
Inhalation	6.40E-02	7.08E-05
Guideline	1.00E+00	1.00E+00

File:TWR3738Rev1/PIT3738R1B

95/5 SST Waste/20 gpm Leak for Limiting Pit Size

Summary of Results   Pit Volume (ft3)   1.02E+04
                                        m³   290

Consequences	Receptor	Conseq.	Guideline	Rev 0-B*
Radiological	Onsite	5.0E-03	5.0E-03	5.1E-03
	Offsite	4.3E-06	1.0E-03	6.6E-06
Toxicological	Onsite	6.4E-02	1.0E+00	1.4E-01
	Offsite	7.1E-05	1.0E+00	7.5E-04

File:TWR3738Rev1/PIT3738R1B

Radiological Consequences							
	Source Terms by Mechanism(L)						
	Pit	WetResus	Gamma	X/Q(s/m3)	BR(m3/s)	ULD(Sv/L)	Dose(Sv)
Onsite Inhalation		0.00E+00		7.57E-04	3.30E-04	2.15E+04	0.00E+00
	2.07E-02			3.41E-02	3.30E-04	2.15E+04	5.00E-03
Gamma*			0.00E+00				0.00E+00
Onsite Total							5.00E-03
Offsite Inhalation		0.00E+00	NA	4.92E-07	3.30E-04	2.15E+04	0.00E+00
	2.07E-02		NA	2.83E-05	3.30E-04	2.15E+04	4.15E-06
Ingestion		0.00E+00		4.92E-07		2.54E-01	0.00E+00
	2.07E-02			2.83E-05		2.54E-01	1.49E-07
Offsite Total							4.30E-06

*Gamma = (Shine+Skyshine for Reference Leak)x(Ratio of Leak Volumes)x(Ratio of Cs137 Activities)

Toxicological Consequences							
	Initial Rates (L/s)		24 hour Rates (L/s)				
Location	Pit	WetResus	Pit	WetResus	Rate (L/s)	SOF Mult	SOF
Onsite	5.75E-06	0.00E+00			5.75E-06	1.11E+04	6.40E-02
Offsite	5.75E-06	0.00E+00	5.75E-06	0.00E+00	5.75E-06	1.23E+01	7.08E-05

File:TWR3738Rev1/PIT3738R1B

APPENDIX C – Base Case Microshield™ and Microskyshine™ Calculations for DST 95/5 Waste Spill

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Material at Risk   4.54E+03 L

DST Gamma Producing Isotopes (Bq/L)

Waste Type	Co-60	Sr-90	Cs-137	Eu-154	Eu-155
DST Liq.	7.00E+06	4.60E+09	5.90E+10	4.20E+07	0
DST Sol.	1.50E+07	5.20E+10	5.90E+10	3.00E+08	0
95/5 Composite	7.40E+06	6.97E+09	5.90E+10	5.49E+07	0.00E+00

Pool Isotopic Inventory (Ci)

Isotope	Co-60	Sr-90	Cs-137	Eu-154	Eu-155
	9.08E-01	8.55E+02	7.24E+03	6.74E+00	0.00E+00

Energy Spectra for 1-Ci of Given Isotopes

	Photons per Second				
MeV	Co-60	Sr-90	Cs-137	Eu-154	Eu-155
0.015		7.80E+08			
0.025		4.00E+08			
0.035		2.60E+08			
0.045		1.80E+08			
0.055		1.40E+08			
0.065		1.10E+08			
0.075		8.90E+07			
0.085		7.40E+07			
0.095		6.30E+07			7.65E+09
0.15		3.30E+08		1.50E+10	
0.25		1.30E+08		2.53E+09	
0.35		6.90E+07			
0.475		5.50E+07		2.65E+09	
0.65	6.04E+06	3.50E+07	3.15E+10		
0.825		1.40E+07		1.54E+10	
1		9.80E+06		1.05E+10	
1.225	7.40E+10	5.50E+06		1.37E+10	
1.475		2.10E+06			
1.7		5.30E+05		1.30E+09	
1.9		1.40E+05			
2.1		1.50E+04			
2.3		8.30E+01			

Combined Energy Spectra (Photons per Second)

	Isotope	Co-60	Sr-90	Cs-137	Eu-154	Eu-155
	Activity (Ci)	9.06E-01	8.55E+02	7.24E+03	6.74E+00	0.00E+00
MeV	Total	Co-60	Sr-90	Cs-137	Eu-154	Eu-155
0.015	6.67E+11	0	6.67086E+11	0	0	0
0.025	3.42E+11	0	3.42095E+11	0	0	0
0.035	2.22E+11	0	2.22362E+11	0	0	0
0.045	1.54E+11	0	1.53943E+11	0	0	0
0.055	1.20E+11	0	1.19733E+11	0	0	0
0.065	9.41E+10	0	94076182182	0	0	0
0.075	7.61E+10	0	76118167568	0	0	0
0.085	6.33E+10	0	63287600000	0	0	0
0.095	5.39E+10	0	53879983784	0	0	0
0.15	3.83E+11	0	2.82228E+11	0	1.00857E+11	0
0.25	1.28E+11	0	1.11181E+11	0	17021480886	0
0.35	5.90E+10	0	59011410811	0	0	0
0.475	6.49E+10	0	47038081081	0	17853423616	0
0.65	2.28E+14	5480143.2	29933324324	2.27992E+14	0	0
0.825	1.16E+11	0	11973329730	0	1.03814E+11	0
1	7.92E+10	0	8381330811	0	70853227784	0
1.225	1.64E+11	67192000000	4703808108	0	92241229135	0
1.475	1.80E+09	0	1795999459	0	0	0
1.7	9.24E+09	0	453276054.1	0	8784911043	0
1.9	1.20E+08	0	119733297.3	0	0	0
2.1	1.28E+07	0	12828567.57	0	0	0
2.3	7.10E+04	0	70984.74054	0	0	0

MicroSkyshine
==============
(Nuclear & Radiological Safety Analysis - 1.16-007)
Page: 1   File Ref: _____
File: Date: __/__/__
  Run: 9:12 a.m.   By: _____
    : December 21, 1998   Checked: _____

CASE: 1,200 gal Spill of 95/5 DST Waste

GEOMETRY: Vertical cylinder area source behind a wall

DIMENSIONS (meters):

Distance between wall and detector........... X   80.
Depth of source behind wall.................. Y   1.
Offset of detector........................... Z   0.
Depth of dose point.......................... H   1.
Distance between center of source and wall... R1   20.
Thickness of cover slab...................... T1   0.
Thickness of second shield................... T2   0.
Radius of source............................. W   6.43
Height of source............................. L   0.035052

INTEGRATION PARAMETERS:

Number of Radial Segments.....................M   5
Number of Circumferential Segments............N   5
Number of Vertical Segments...................C   5
Quadrature Order.................................. 16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
Air			
Water			
Concrete			1.4
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: CONCRETE.

Page 2

CASE: 1,200 gal Spill of 95/5 DST Waste

SOURCE NUCLIDES:

Source was entered by energy groups.

RESULTS:

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.70	9.240e+09	5.615e-20	2.139e-03
2	1.48	1.800e+09	5.508e-20	4.088e-04
3	1.23	1.640e+11	6.129e-20	4.145e-02
4	1.00	7.920e+10	6.192e-20	2.022e-02
5	.82	1.160e+11	5.904e-20	2.824e-02
6	.65	2.280e+14	6.083e-20	5.719e+01
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
TOTALS:		2.284e+14		5.728e+01

MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page   : 1   File Ref: _____
DOS File: DST-POOL.MS4   Date: __/__/__
Run Date: December 21, 1998   By: _____
Run Time: 9:16 a.m. Monday   Checked: _____
Duration: 0:00:01

Case Title: 1,200 gal Spill of 95/5 DST Waste

GEOMETRY 8 - Cylinder Volume - End Shields

	centimeters	feet and inches	
Dose point coordinate X:	10000.0	328.0	1.0
Dose point coordinate Y:	100.0	3.0	3.4
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	3.5052	0.0	1.4
Cylinder radius:	643.0	21.0	1.1
Air Gap:	96.4948	3.0	2.0
Side Clad:	8000.0	262.0	5.6

Source Volume: 4.55286e+6 cm^3   160.783 cu ft.   277833. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Air Gap	Side Clad Shield	Immersion Shield
Air		0.00122		0.00122
Concrete	1.4		1.4	

BUILDUP
Method: Buildup Factor Tables
The material reference is Source

INTEGRATION PARAMETERS

	Quadrature Order
Radial	10
Circumferential	10
Axial (along Z)	10

SOURCE WAS ENTERED AS ENERGIES ONLY

Page   : 2
DOS File: DST-POOL.MS4
Run Date: December 21, 1998
Run Time: 9:16 a.m. Monday
Title   : 1,200 gal Spill of 95/5 DST Waste

```
=========================== RESULTS ===========================
Energy    Activity      Energy Fluence Rate    Exposure Rate In Air
(MeV)   (photons/sec )     (MeV/sq cm/sec)            (mR/hr)
                        No Buildup  With Buildup  No Buildup  With Buildup
 0.65    2.280e+014     1.164e+003  4.429e+003   2.261e+000   8.599e+000
 0.825   1.160e+011     9.251e-001  3.104e+000   1.753e-003   5.882e-003
 1.0     7.920e+010     9.045e-001  2.756e+000   1.667e-003   5.081e-003
 1.225   1.640e+011     2.735e+000  7.573e+000   4.842e-003   1.340e-002
 1.475   1.800e+009     4.237e-002  1.081e-001   7.161e-005   1.827e-004
 1.7     9.240e+009     2.823e-001  6.807e-001   4.585e-004   1.106e-003

TOTAL:   2.284e+014     1.169e+003  4.443e+003   2.269e+000   8.624e+000
```

APPENDIX D – Record of Review, Peer Review and HEDOP Review

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Preparation and Review of	Manual	HNF-2353
Calculation Notes	Desk Instruction	4.3, Rev. 0
	Page	8 of 8
	Effective Date	June 10, 1999

ATTACHMENT C

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: TWR-3738, Rev 1 Mitigated Transfer Line Leaks that Result in Surface Pool

Scope of Review: Entire Document

Yes No NA

[X] [] [] Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps.

[X] [] [] Problem is completely defined.

[X] [] [] Accident scenarios are developed in a clear and logical manner.

[X] [] [] Necessary assumptions are explicitly stated and supported.

[X] [] [] Computer codes and data files are documented.

[X] [] [] Data used in calculations are explicitly stated.

[X] [] [] Data were checked for consistency with original source information as applicable.

[] [] [X] Mathematical derivations were checked including dimensional consistency of results.

[X] [] [] Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity.

[X] [] [] Spreadsheet results and all hand calculations were verified.

[X] [] [] Software input is correct and consistent with the document reviewed.

[X] [] [] Software output is consistent with the input and with the results reported in the document reviewed.

[X] [] [] Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references.

[X] [] [] Safety margins are consistent with good engineering practices.

[X] [] [] Conclusions are consistent with analytical results and applicable limits.

[X] [] [] Results and conclusions address all points in the purpose.

[X] [] The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".

[X] [] [] Concurrence

John C Van Keuren   JC Van Keuren   10/14/99
Reviewer (Printed Name and Signature)   Date

Preparation and Review of	Manual	HNF-2353
Calculation Notes	Desk Instruction	4.3, Rev. 0
	Page	8 of 8
	Effective Date	June 10, 1999

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CHECKLIST FOR TECHNICAL PEER REVIEW

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[X]	[ ]	[ ]	Accident scenarios are developed in a clear and logical manner.
[X]	[ ]	[ ]	Necessary assumptions are explicitly stated and supported.
[X]	[ ]	[ ]	Computer codes and data files are documented.
[X]	[ ]	[ ]	Data used in calculations are explicitly stated.
[X]	[ ]	[ ]	Data were checked for consistency with original source information as applicable.
[ ]	[ ]	[X]	Mathematical derivations were checked including dimensional consistency of results.
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[X]	[ ]	[ ]	Spreadsheet results and all hand calculations were verified.
[X]	[ ]	[ ]	Software input is correct and consistent with the document reviewed.
[X]	[ ]	[ ]	Software output is consistent with the input and with the results reported in the document reviewed.
[X]	[ ]	[ ]	Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references.
[X]	[ ]	[ ]	Safety margins are consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions are consistent with analytical results and applicable limits.
[X]	[ ]	[ ]	Results and conclusions address all points in the purpose.
[X]	[ ]		The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".

[X] [ ] [ ] Concurrence

John C Van Keuren _(signature)_ 11/29/99
Reviewer (Printed Name and Signature)   Date