Appendix D

Determination of Frequencies for Selected Accidents

Table D-1, Documentation of Basic Event Variables Used in the quantification of RH Waste Accident Frequencies

ID	Description	Value	Units	Source/Comments
f_fueltank leak	Frequency of leaks in an unpressurized fuel tank	1.00E-07	/op.hr	Ref. WSRC-TR-93-262, Table 1b. The value in Table 1b is based on a generic tank. The tanks on the forklift are more reliable because they conform to MSA requirements.
f_forklift_drop_site	Frequency of forklift equipment failures producing waste canister drops, considering all the forklift operations accomplished during a typical operational year at a typical operational DOE site	4.30E-03	/site-year	Ref. INEL-94/0228. Table B-1, p. B-10. Estimate based on very broad arguments on a site wide basis.
f_forklift_coll_site	Frequency of forklift equipment failures producing punctures, considering all the forklift operations accomplished during a typical operational year at a typical operational DOE site	1.30E-02	/site	Ref. INEL-94-0228, Table B-1, p. B-10. Estimate based on very broad arguments on a site wide basis. This value forms the basis for frequency of forklift collisions per operating hour, f_forklift_coll.
f_hoist_brake	Failure of hoist braking system, given loss of power to hoist lifting equipment.	1.30E-07	/demand	Ref. WIPP/WID-96-2178. Waste Hoist Brake system Analysis. Average unavailability of brake system based on anticipated annual usage, (see p. A3-18 of report for top event unavailability definition)
f_LOSP	Frequency of loss of offsite power from the STS	2.20E-01	/yr.	Ref. DOE/WIPP-95-2065, Rev.2 Table D-12. Based on 3 events at WIPP in 13.8 years.
f_Loss_onsite_pwr	Frequency of loss of distribution of power onsite to critical lifting equipment	2.20E-01	/yr.	Ref. DOE/WIPP-95-2065, Rev.2 Table D-12. Based on 3 events at WIPP in 13.8 years.
H_filter_UG1	HEP for filter to transfer to underground filtration mode, given a release of TRU waste in the underground during active emplacement of waste. Approximately 2 minutes available to act before material transits from U/G to the surface.	1.00E-01	/demand	Ref. WSRC-TR-93-581, Action 2. Estimate for failure to take immediate action. A potential release is considered a compelling signal to act. High mean value selected, because of the potential for injuries compete for attention and limited time.
H_forklift_drop	HEP for failure to control a forklift during a waste handling operations, resulting in a drop	1.00E-05	/operation	Ref. WSRC-TR-93-581. Action 25. Low value used because the forklift is used in a consistent and repetitious manner for waste transfers, and favorable working conditions must exist for waste handling operations to proceed. A spotter is also present.

Table D-1, Documentation of Basic Event Variables Used in the quantification of RH Waste Accident Frequencies

ID	Description	Value	Units	Source/Comments
H_forklift_punct	Collision due to human error	5.00E-06	/op	Ref. WSRC-TR-93-581, Action 26. Low value is used because the forklift is used in a consistent and repetitious manner for waste transfers. The forklift transfer in the underground is a standard operation done under excellent working conditions and a spotter is present. Floor will be leveled prior to storage operations in a panel room.
L_canister_bre	Likelihood that a waste canister is breached given that it falls from < 22 ft.	6.20E-01	/event	Ref. PLG-1121. This scenario considers a stacked 7-pack of CH waste drums. The RH waste canister is similar to SWB for CH waste. According to PLG-1121, no loss of content was apparent when two SWB's were dropped from 25 ft.
L_canister_fire	Likelihood that a waste canister is breached, given a fire adjacent to the waste canister	4.00E-02		Ref. DOE/WIPP-87-005, Likelihood of thermal breach, sum of items (22) through (25), increased by a factor of 10 to account for more energetic external fire. The increase is judged to be conservatively reasonable, since fuel fires initiated by collisions could be more energetic than a waste drum fire.
L_filter_UG1	Likelihood of failure to auto-transfer to underground filtration mode, given a gradual release of TRU waste in the underground	1.00E+00	/demand	Worst case assumption. No credit taken for the ability of the time integrated control logic to prevent a puff release.
L_filter_WHB	Likelihood the on-line HEPA filter is open or bypassed, given a release of TRU waste in the WHB, and is therefore unavailable to accomplish its function. (Primary cause is human error that leaves the HEPA filter in an undetected bypassed condition)	1.00E-04	/event	This condition requires alignment error at the filter and lack of monitoring by the CMRO. Given the HEPA filter is required to be on-line and the delta-p across the HEPA filter is monitored in the CMR, the estimate is judged to be conservative.
L_fire_punct	Likelihood that a fire is ignited, given forklift collision or leak during waste handling operations in the underground	5.00E-04		Ref. DOT, Traffic Safety Facts 1997, Table 38, shows <0.05% vehicles involved in fire for all crashes of "Bus" vehicles.
N_wc_yr	Bounding number of RH waste hoist or forklift (in UG) transfers per year	6.93E+02	/yr.	Based on current estimated throughput. Assumes one hoist transfer and one forklift operation per waste canister
T_forklift_op	Average time that a forklift requires to transfer one waste canister to the emplacement equipment in UG	4.00E+00	hours	Based on current training activities, operations personnel estimate that the time to transfer one waste canister to the emplacement equipment is approximately 30 minutes.
T_hoist_UG	Duration of time that the hoist supports waste during one transfer to the underground (hours)	2.00E-01	hours	Ref. WIPP/WID-96-2178,P.3-3. Estimates 8.6 min. cycle time per lift at 500 ft/min. Time rounded to 0.2 hours to account for any additional brake release time that might be required

Table D-1, Documentation of Basic Event Variables Used in the quantification of RH Waste Accident Frequencies

ID	Description	Value	Units	Source/Comments
FIgnition(ES)	The probability of an electrical short igniting a fire in the Hot Cell in one year	5.00E-04	/yr.	Per WSRC-TR-93-26234, the failure of a circuit breaker or fuse is 5.0E-04/demand. If it is conservatively assumed that an electrical short in the equipment in the Hot Cell is present with waste stored in the Hot Cell, then the probability of a fire initiated by an electrical short can be approximated as the demand failure of the circuit breaker or fuse.
FComb	The probability of having sufficient combustibles to generate a large enough fire to ignite the waste material in a drum	1.00E-04		The probability of having sufficient combustible material in the Hot Cell to generate a large enough fire to ignite the waste material in a drum can be equated to a human error in failing to properly follow procedures. For this case, it is assumed that the failure to properly meet the combustible control program requirements would involve an error to accomplish a clear, unambiguous task and the failure of a checker (not independent in time) to detect the error. Per DOE/WIPP-95-2065, Rev 4
L_oxidant	The probability that there is sufficient oxidant in a waste drum to support a sustained fire	4.20E-03		Per DOE/WIPP-95-2065, Rev 4
NDrums	Bounding number of waste drums handled in one year	2.08E+03	op/yr.	Based on current estimated throughput.
F Exp Mix	Probability of explosive gas mixture in drum	1.00E-04		The probability of having an explosive gas mixture in a waste drum can be equated to a human error in failing to properly follow procedures in the preparation of the drum for shipment to WIPP. Per DOE/WIPP-95-2065, Rev 4
F Exp Mix Can	Probability of explosive gas mixture in drum in WIPP Canister	3.00E-04		Since there are three waste drums in each facility canister at the time the canister lid is welded, the probability that there is a waste drum with an explosive gas mixture in the canister at the time of welding is 3 times The probability of having an explosive gas mixture in a waste drum.
F Ignition (Weld)	The probability of generating a spark that ignites the flammable gas in a waste drum during welding	0.00E+00	/event	Welder removed from service- no welding performed in Hot Cell
NCanisters	The total number of canisters handled per year	6.93E+02	op/yr.	Since there are three waste drums per canister, the total number of canisters handled per year is 2080/3 or 693 canisters
FDrop	The probability of a crane drop per lift	3.40E-06		Due to all mechanisms (i. e., equipment failure and human error). Per DOE/WIPP-95-2065, Rev 4
NCask	The maximum number of 10-160B casks that will be process in one year.	2.08E+02	op/yr.	Based on current estimated throughput.
NCarriage	Number of drum carriages lifted per year	4.16E+02	op/yr.	There are two drum carriages in each 10-160B road cask. Therefore, if 208 10-160B casks are processed each year, 416 drum carriages will be lifted

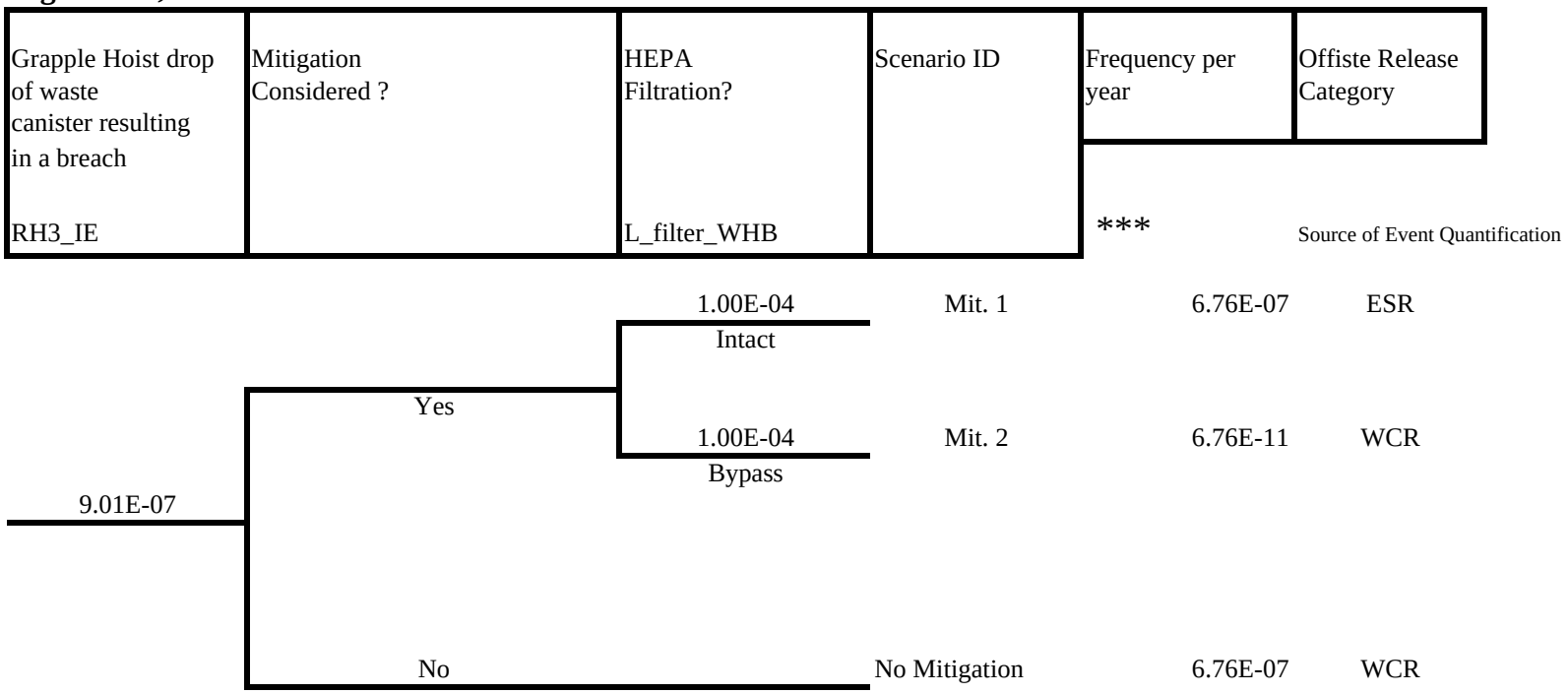
Table D-1, Documentation of Basic Event Variables Used in the quantification of RH Waste Accident Frequencies

ID	Description	Value	Units	Source/Comments
FCrane Strike	The probability of striking a stationary object with a remotely operated crane	3.00E-03		From WSCR-TR-93-58133: This probability is assumed to apply in this case by assuming that the human error failure rate dominates the equipment (hardware) failure rate that could result in the crane striking the lifting fixture.
FDrum Plac	The probability that a waste drum is mis-positioned and left in a location where it can be struck by the falling shield plug lift fixture	1.00E-04		This event is modeled as a human error for failure to properly follow procedures and the failure of the checker. Per DOE/WIPP-95-2065, Rev 4
FDrum Fail	The probability that a drum is failed by a drop in the Hot Cell	3.00E-01		Per DOE/WIPP-95-2065, Rev 4, the probability that one drum in a seven pack that is dropped ten feet fails is given as 0.62. However, this probability includes the crushing effect of the other drums in the package. Since in this case a single drum is dropped, the probability of failure would be lower and is assumed to be 0.3, half the probability from the given reference.
FStrike	The frequency of striking the drum the the PAR manipulator arm.	1.00E-03		This event is equivalent to the failure to follow a clear, unambiguous procedure.
FClosing	The probability of a shield valve closing on the canister.	2.00E-13		Per PLG 1317.
FDrum Rupture	The probability of rupturing the canister.	2.00E-03		EANL/EAD/TM-29 provides estimates of the conditional probability of rupture of a waste drum due to impact during waste handling operations. Since the WIPP Canister is more robust than a waste drum, it is expected that it would be less likely to suffer rupture from an impact than a waste drum would.
FCrane	The probability of suprious movement of the crane	1.00E-03		The spurious movement of the crane during transfer of the WIPP Canister could be the result of either human error or equipment failure. However, EEG 74 indicates that 90 to 95% of all crane incidents are caused by operator error. Therefore, for this analysis it is assumed that the spurious movement of the crane is due to an operator error.
FShutt Car Mov	The probability of suprious movement of the Shuttle Car	3.30E-12		PLG-1317, Waste Isolation Pilot Plant 6.25 Grapple Hoist Fault Tree Analysis
FGas Btl Moved	The probability of a gas bottle movement (operator error) with a 10-160B cask is in the RH Bay	1.00E-04		Per DOE/WIPP-95-2065, Rev 4, this can be equated to the probability of a human errer in failing to properly follow procedures and the failure of a checker (not independent in time) to detect the error.
FCask Hit	The probability of the random direction of the gas bottle missile hitting the cask head.	1.40E-02		Per DOE/WIPP-95-2065, Rev 4
FMissile	The frequency for a gas bottle to fall and become a missile	2.00E-02		It is conservatively assumed that this sequence of events has a conditional probability. Because of the round shape and robustness of the Type B Shipping Cask, the missile must make a head-on strike of the cask.
F Ignition (OE)	The probability of generating a spark that ignites the flammable gas in a waste drum	1.00E-03	/event	Per DOE/WIPP-95-2065, Rev 4, this can be equated to the probability of a human errer in failing to properly follow procedures.

Table D-2, RH3 - Loss of Confinement in the Waste Handling Building

Variable Name	Description	Formula	Resulting value	Comments
RH3_IE	Frequency of Grapple Hoist Drops resulting in a breach of the canister per year	F_hoist _drop * N_wc_yr	9.01E-07	Grapple hoist drops canister back into Transfer Cell
N_wc_yr	Bounding number of RH waste canisters transferred by grapple hoist into the facility cask	N_wc_yr	6.93E+02	Based on current estimated throughput.
F_hoist_drop	Frequency of grapple hoist drop resulting in a breach of the canister per demand	F_hoist _drop	1.30E-09	Ref. PLG-1317, Waste Isolation Pilot Plant 6.25 Grapple Hoist Fault Tree Analysis

Figure D-1, Event Tree for RH3 - Loss of Confinement in the WHB



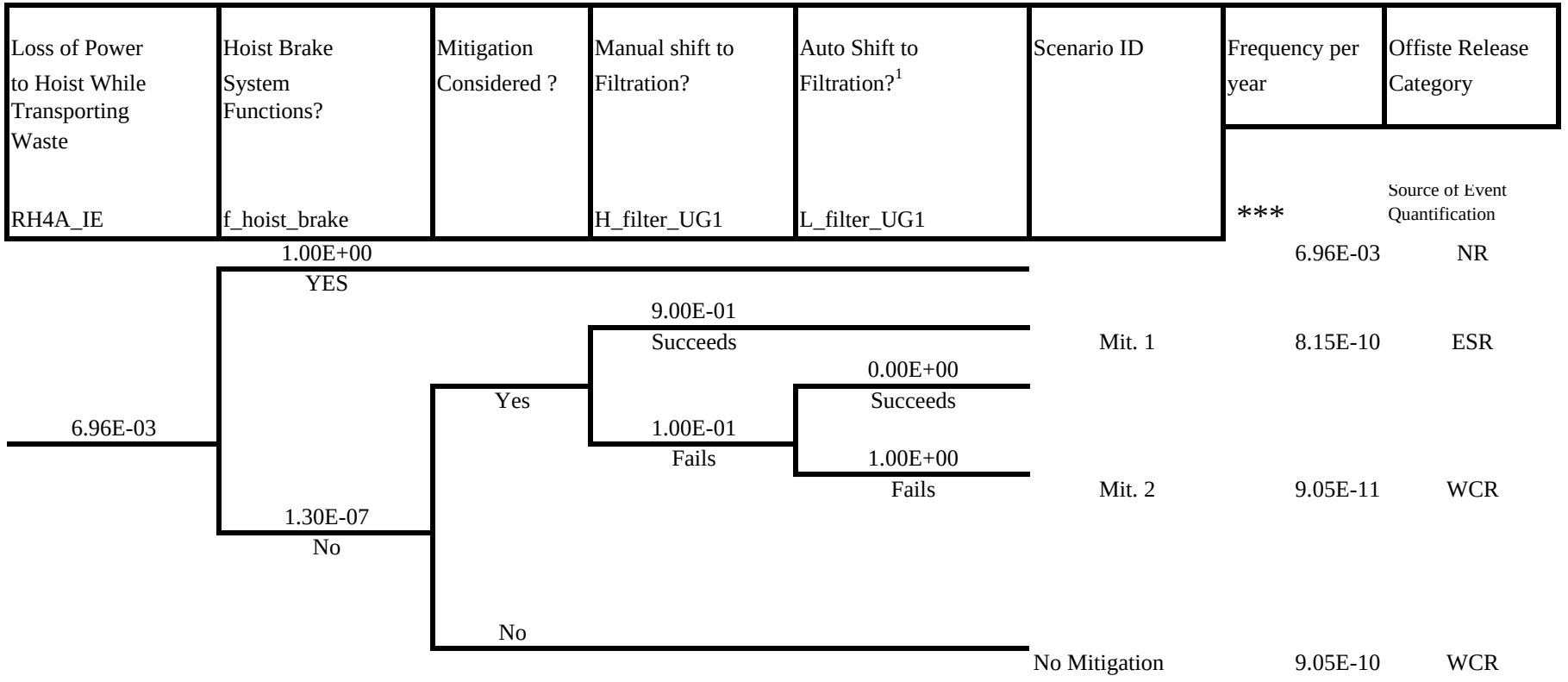
LEGEND:

NR:	**No Release**
ESR:	**Extremely Small Release**
SR:	**Small Release**
WCR:	**Worst Case Release**

Table D-3, Initiator for Event 8-6 in RH4A - Loss of Power to Hoist While Waste is being Transferred to the Underground

Variable Name	Description	Formula	Resulting value	Comments
RH4A_IE	Frequency of loss of power to hoist while transferring waste to the underground	f_Loss _pwr_hoist *T_hoist_yr	6.96E-03	Constitutes dominant demand for brake system to function without backup.
f_loss_pwr_hoist		f_LOSP + f_Loss_onsite_pwr	4.40E-01	Power lost due to either the loss of the source or the loss of distribution. Onsite power sources will not come on line quickly enough to prevent a requirement for the hoist brake system to function upon loss of power
f_LOSP	Frequency of loss of offsite power from the STS	f_LOSP	2.20E-01	Ref.DOE/WIPP-95-2065,Rev.2, Table D-12. Based on 3 events at WIPP in 13.8 years.
f_Loss_onsite_pwr	Frequency of loss of distribution of power onsite to critical lifting equipment	f_Loss_onsite_pwr	2.20E-01	Ref.DOE/WIPP-95-2065,Rev.2, Table D-12. Based on 3 events at WIPP in 13.8 years.
N_wc_yr	Bounding number of RH waste hoist transfers per year	N_wc_yr	6.93E+02	Based on current estimated throughput.
T_hoist_yr	Time that hoist supports waste over a year of operation	N_wc_yr * T_hoist_op	1.39E+02	Total exposure time of the hoist to events that could require brakes to function to prevent a waste drop.
T_hoist_op	Duration of time that the hoist supports waste during one transfer to the underground (hours)	T_hoist_op	2.00E-01	Ref. WIPP/WID-96-2178, P 3-3. Estimates 8.6 min. cycle timer per lift at 500 ft/min. Time rounded to 0.2 hours to account for any additional brake release time that might be required.

Figure D-2, Event Tree for RH4A - Loss of Confinement in the UG - Waste Hoist Failure



LEGEND:

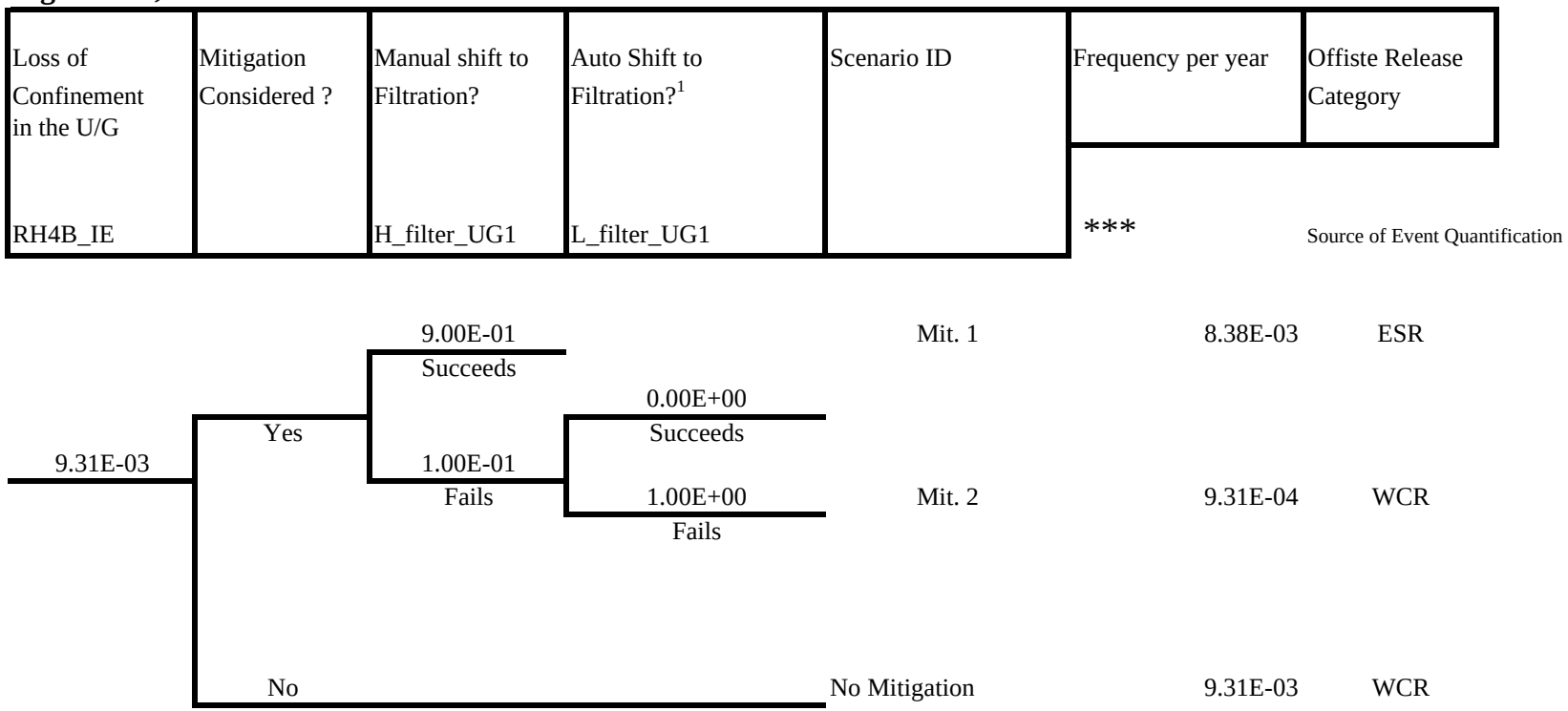
NR:	**No Release**
ESR:	**Extremely Small Release**
SR:	**Small Release**
WCR:	**Worst Case Release**

[1]No credit taken for Auto Shift to Filtration

Table D-4, RH4-B - Loss of Confinement in the Underground

Variable Name	Description	Formula	Resulting val	Comments
RH4B_IE	Drop of waste canister in the underground	N_wc_yr * f_wc_UG	9.31E-03	Frequency on an annual basis is the product of the number of operations in which a breach could occur and the accident rate per operation.
f_wc_UG	Frequency of waste canister drops from forklift during waste handling operations in the UG horizon	H_forklift_drop + f_hardware	1.34E-05	Drop may occur due to either human error or hardware failure.
H_forklift_drop	Drop due to human error	H_forklift_drop	1.0E-05/op	The forklift transfer in the underground is a standard operation done under excellent working conditions. Floor will be leveled prior to storage operations in a panel room. A spotter is also present. See Table D-1 for variable documentation.
f_hardware	Drop due to forklift hardware failure	f_forklift_drop * T_forklift_UG	3.44E-06	Forklift hardware failures result from time related mechanisms during operation, but only produce drops during the time period when the forklift is handling waste.
N_wc_yr	Bounding number of RH waste forklift operations per year	N_wc_yr	6.93E+02	Based on current estimated throughput. Assumes one forklift operation per waste canister.
f_forklift_drop	Frequency of forklift hardware failures (lifting mechanism, suspension, structure) resulting in drops of waste canister during waste handlingoperations	f_forklift_drop_site /(10 forklifts * 2000 op.hours * 0.25 usage factor for forklift)	8.60E-07	Scoping estimate based on estimate of a typical site year. At WIPP pre-operational checks are accomplished before each shift.
f_forklift_drop_site	Frequency of forklift equipment failures producing waste canister drops, considering all the forklift year at a typical operational DOE site operations accomplished during a typical operational	f_forklift_drop_site	4.3E-03/site yr	Ref. INEL-94/0228, Table B-1, p. B-10. Estimate based on very broad arguments on a site wide basis.
T_forklift_UG	Average time that a forklift requires to transfer one waste canister to the emplacement equipment in UG	T_forklift_UG	4.0 hr	Based on current training activities, operations personnel estimate that the time to transfer one waste canister to the emplacement equipment is approximately 30 minutes.

Figure D-3, Event Tree for RH4B - Loss of Confinement in the UG - Forklift



LEGEND:

NR:	**No Release**
ESR:	**Extremely Small Release**
SR:	**Small Release**
WCR:	**Worst Case Release**

[1]No credit taken for Auto Shift to Filtration

Table D-5 - RH6 Seismic Event

This section develops the scenario initiating event probability assuming that the preventative and mitigative measures function as designed during the accident scenario.

As discussed in (1) in the existing WIPP CH SAR, DOE/WIPP-95-2065, Rev.2, (2) the Project Technical Baseline for Regulatory Compliance WP 02-RC1, and (3) Final Environmental Impact Statement DOE/EIS-0026, UC-70, the Design Basis Earthquake (DBE) is the most severe credible earthquake that could occur at the WIPP site. The DBE is based on a 1000-yr return interval established through a site specific study. The maximum ground acceleration for the DBE is 0.1 g in both the horizontal and vertical directions, with 10 maximum stress cycles.

Based on analysis done at Savannah River Site, the frequency of a fire after an Unlikely Seimic event is in the Extremely Unlikely frequency range (Ref. 9).

Table D-6 - RH7 Tornado Event

This section develops the scenario initiating event probability assuming that the preventative and mitigative measures discussed in Table 5.1-9 function as designed during the accident scenario.

As discussed in (1) in the existing WIPP CH SAR, DOE/WIPP-95-2065, Rev.2, (2) the Project Technical Baseline for Regulatory Compliance WP 02-RC1, and (3) Final Environmental Impact Statement DOE/EIS-0026, UC-70, the Design Basis Tornado (DBT) is the most severe credible tornado (183 mi/hr) that could occur at the WIPP site, based on a 1,000,000-yr. recurrence period.

The DBT was developed by a site specific study SMRP No. 155, "A Site-Specific Study of Wind and Tornado Probabilities at the WIPP Site in Southeast New Mexico," Department of Geophysical Sciences, T. Fujita, University of Chicago, February 1978 and its Supplement of August 1978 (Ref. 10).

Table D-7, NC1 - Fire in Hot Cell

Variable Name	Description	Formula	Resulting value	Comments
F9-1	The frequency of a fire occuring in the Hot Cell while containing stored waste	FIgnition(ES) * Fcomb * L_oxidant * NDrums	4.37E-07	In order for an electrical short to ignite a fire, an electrical fault must occur and the protective device on the circuit (i. e., circuit breaker or fuse) must fail to operate to clear the fault.
FIgnition(ES)	The probability of an electrical short igniting a fire in the Hot Cell in one year	FIgnition(ES)	5.00E-04	Per WSRC-TR-93-26234, the failure of a circuit breaker or fuse is 5.0E-04/demand. If it is conservatively assumed that an electrical short in the equipment in the Hot Cell is present with waste stored in the Hot Cell, then the probability of a fire initiated by an electrical short can be approximated as the demand failure of the circuit breaker or fuse.
FComb	The probability of having sufficient combustibles to generate a large enough fire to ignite the waste material in a drum	FComb	1.00E-04	The probability of having sufficient combustible material in the Hot Cell to generate a large enough fire to ignite the waste material in a drum can be equated to a human error in failing to properly follow procedures. For this case, it is assumed that the failure to properly meet the combustible control program requirements would involve an error to accomplish a clear, unambiguous task and the failure of a checker (not independent in time) to detect the error. Per DOE/WIPP-95-2065, Rev 4
L_oxidant	The probability that there is sufficient oxidant in a waste drum to support a sustained fire	L_oxidant	4.20E-03	Per DOE/WIPP-95-2065, Rev 4
NDrums	Bounding number of RH waste drums transferred by grapple hoist into the facility cask per year	NDrums	2.08E+03	Based on current estimated throughput.
L_filter_WHB	Likelihood the on-line HEPA filter is open or bypassed, given a release of TRU waste in the WHB, and is therefore unavailable to accomplish its function. (Primary cause is human error that leaves the HEPA filter in an undetected bypassed condition)	1.00E-04	/event	This condition requires alignment error at the filter and lack of monitoring by the CMRO. Given the HEPA filter is required to be on-line and the delta-p across the HEPA filter is monitored in the CMR, the estimate is judged to be conservative.

Figure D-4, Event Tree for NC-1 - Fire in Hot Cell (9-1)

Drums per Year	Ignition Source (Electrical Short)	Combustibles Present	Sufficient Oxidant in Drum	HEPA Filtration	Drum Breach Frequency (per Year)		
N_{Drums}	$F_{Ignition(ES)}$	F_{Comb}	L_oxidant	L_filter_WHB	F_{9-1}		
2.08E+03	5.00E-04 yes	1.00E-04 yes	4.20E-03 yes	1.00E+00 Bypass		4.37E-07	**WCR**
				1.00E-04 Intact		4.37E-11	**ESR**
			9.96E-01 no			None	**NR**
		1.00E+00 no				None	**NR**
	1.00E+00 no					None	**NR**
					Total Frequency	4.37E-07	

LEGEND:

NR: No Release
ESR: Extremely Small Release
SR: Small Release
WCR: Worst Case Release

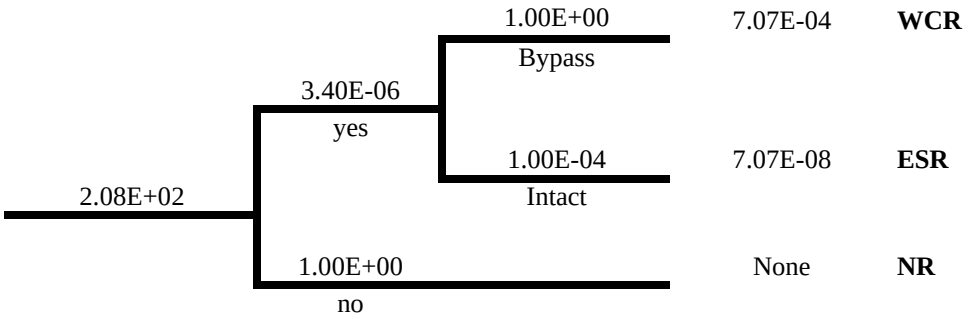
Table D-8, NC3-A - Dropped Object on Waste in Hot Cell

Variable Name	Description	Formula	Resulting value	Comments
F4F-1	The frequency of dropping the shield plug (which separates the Hot Cell from the CUR) on a WIPP Canister in the Hot Cell	NCask * FDrop	7.07E-04	The frequency of this event is a function of the number of 10-160B road casks that are processed each year and the probability of dropping the shield plug while it is being removed.
NCask	The maximum number of 10-160B casks that will be process in one year.	NCask	2.08E+02	Based on current estimated throughput.
FDrop	The probability of a crane drop per lift	FDrop	3.40E-06	Due to all mechanisms (i. e., equipment failure and human error). Per DOE/WIPP-95-2065, Rev 4
F4H-1	The frequency of dropping the cask lid on waste drums in the Hot Cell	NCask * FDrop	7.07E-04	The frequency of this event is a function of the number of 10-160B road casks that are processed each year and the probability of a crane drop
F5CE-2	The frequency of dropping the a drum carriage on waste stored in the hot cell	FDrop * NCarriage	1.41E-03	The frequency of this event is a function of the number of waste drum carriages handled per year and the probability of dropping the carriage while it is being lifted
NCarriage	Number of drum carriages lifted per year	NCarriage	4.16E+02	There are two drum carriages in each 10-160B road cask. Therefore, if 208 10-160B casks are processed each year, 416 drum carriages will be lifted
F9-5	The frequency of knocking over the shield plug lifting fixture by striking it with the crane or its load	NDrums * FCrane Strike * FDrum Plac	6.24E-04	The frequency of this event is a function of the number of crane operations that are close to the shield plug lifting fixture stand and the probability of a human error that results in striking the shield plug lifting fixture with the crane or its load such that it falls over and strikes waste stored in the Hot Cell.
NCanisters	The total number of canisters handled per year	NCanisters	6.93E+02	Since there are three waste drums per canister, the total number of canisters handled per year is 2080/3 or 693 canisters
FCrane Strike	The probability of striking a stationary object with a remotely operated crane	FCrane Strike	3.00E-03	From WSCR-TR-93-58133: This probability is assumed to apply in this case by assuming that the human error failure rate dominates the equipment (hardware) failure rate that could result in the crane striking the lifting fixture.
FDrum Plac	The probability that a waste drum is mis-positioned and left in a location where it can be struck by the falling shield plug lift fixture	FDrum Plac	1.00E-04	This event is modeled as a human error for failure to properly follow procedures. Per DOE/WIPP-95-2065, Rev 4
F9AC-1	The frequency of dropping an empty WIPP Canister on drums in the Hot Cell.	Ncanisters * FDrop	2.36E-03	The frequency of this event is a function of the number WIPP Canisters handled per year and the probability of dropping the canister while it is being lifted.
L_filter_WHB	Likelihood the on-line HEPA filter is open or bypassed, given a release of TRU waste in the WHB, and is therefore unavailable to accomplish its function. (Primary cause is human error that leaves the HEPA filter in an undetected bypassed condition)	1.00E-04	/event	This condition requires alignment error at the filter and lack of monitoring by the CMRO. Given the HEPA filter is required to be on-line and the delta-p across the HEPA filter is monitored in the CMR, the estimate is judged to be conservative.

Figure D-5, Event Tree for NC3-A Dropped Object on Waste Material in Hot Cell
(4F-1, 4H-1, 5CE-2, 9AC-1, 9-5)

4F-1, 4H-1 Cask Lid Drop

Lifts per Year	Crane Drop per Lift	HEPA Filtration	Container Breached Frequency (per Year)
N_{Cask}	F_{Drop}	L_filter_WHB	$F_{4F-1, 4H-1}$



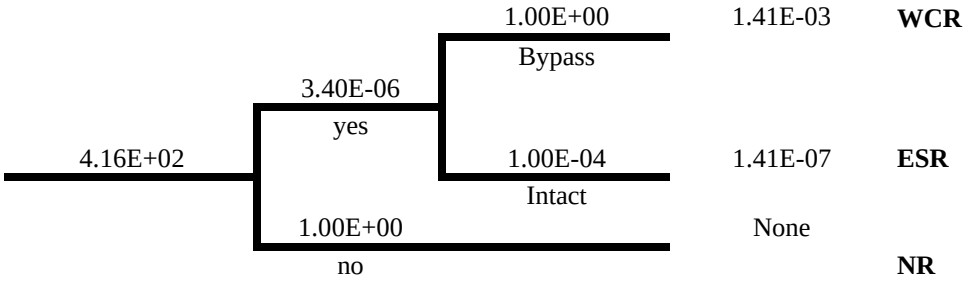
Total Frequency **7.07E-04**

LEGEND:
NR: No Release
ESR: Extremely Small Release
SR: Small Release
WCR: Worst Case Release

Figure D-5, Event Tree for NC3-A Dropped Object on Waste Material in Hot Cell

5CE-2 Drum Carriage Drop

Lifts per Year	Crane Drop per Lift	HEPA Filtration	Container Breached Frequency (per Year)
$N_{Carriage}$	F_{Drop}	L_filter_WHB	F_{5CE-2}



Total Frequency **1.41E-03**

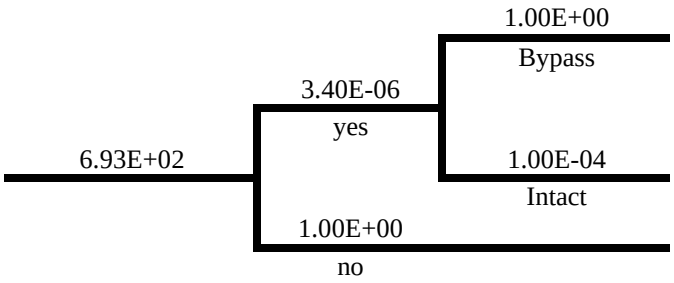
LEGEND:
NR: No Release
ESR: Extremely Small Release
SR: Small Release
WCR: Worst Case Release

Figure D-5, Event Tree for NC3-A Dropped Object on Waste Material in Hot Cell

1.41E-07

9AC-1 Empty Canister Drop

Lifts per Year	Crane Drop per Lift	HEPA Filtration	Container Breached Frequency (per Year)
$N_{Canisters}$	F_{Drop}	L_filter_WHB	F_{9AC-1}



2.36E-03	**WCR**	
2.36E-07	**ESR**	
None	**NR**	
2.36E-03		

Total Frequency

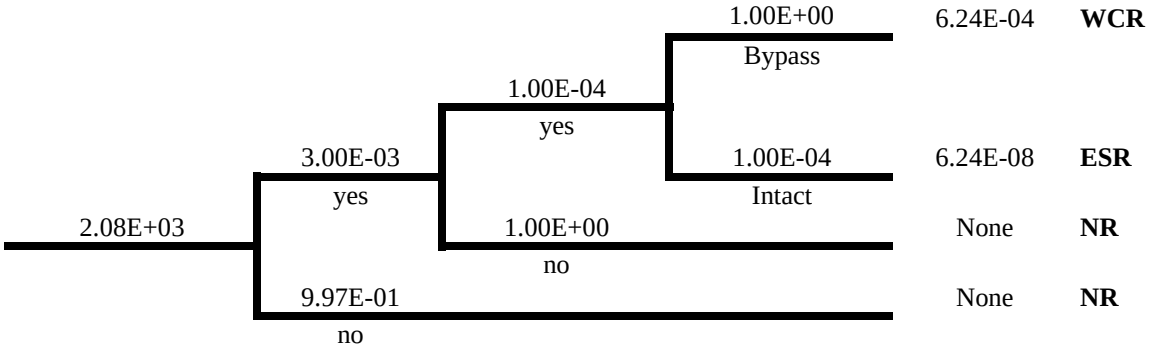
LEGEND:

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

Figure D-5, Event Tree for NC3-A Dropped Object on Waste Material in Hot Cell

9-5 Inadvertent Knocking over Shield Plug Fixture into Misplaced Drum

Lifts per Year	Crane Strikes Fixture per Lift	Drum Placed within Range of Falling Fixture	HEPA Filtration	Drum Breached Frequency (per Year)
Ndrum	$F_{Crane\ Strike}$	$F_{Drum\ Plac}$	L_filter_WHB	F_{9-5}



Total Frequency **6.24E-04**

LEGEND:
NR: No Release
ESR: Extremely Small Release
SR: Small Release
WCR: Worst Case Release

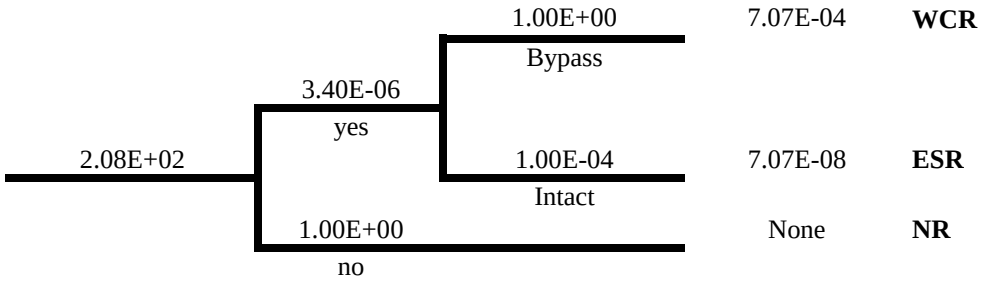
Table D-9, NC3-B - Dropped Object on Waste Material Outside Hot Cell

Variable Name	Description	Formula	Resulting value	Comments
F4G-1	The frequency of dropping the 10-160B cask lid on the waste drums	NCask * FDrop	7.07E-04	The frequency of this event is a function of the number of 10-160B road casks that are processed each year and the probability of cask lid being dropped while it is being removed.
NCask	The maximum number of 10-160B casks that will be processed in one year.	NCask	2.08E+02	Based on current estimated throughput.
FDrop	The probability of a crane drop per lift	FDrop	3.40E-06	Due to all mechanisms (i. e., equipment failure and human error). Per DOE/WIPP-95-2065, Rev 4
F5BD-1	The frequency of dropping the a drum carriage lifting fixture on the drums after the cask lid has been removed.	FDrop * NCarriage	1.41E-03	The frequency of this event is a function of the number of waste drum carriages handled per year and the probability of dropping the carriage while preparing to remove the waste drum carriages from the cask.
NCarriage	Number of drum carriages lifted per year	NCarriage	4.16E+02	There are two drum carriages in each 10-160B road cask. Therefore, if 208 10-160B casks are processed each year, 416 drum carriages will be lifted
L_filter_WHB	Likelihood the on-line HEPA filter is open or bypassed, given a release of TRU waste in the WHB, and is therefore unavailable to accomplish its function. (Primary cause is human error that leaves the HEPA filter in an undetected bypassed condition)	1.00E-04	/event	This condition requires alignment error at the filter and lack of monitoring by the CMRO. Given the HEPA filter is required to be on-line and the delta-p across the HEPA filter is monitored in the CMR, the estimate is judged to be conservative.

Figure D-6, Event Tree for NC3-B Dropped Object on Waste Material Outside Hot Cell

4G-1 Cask Lid Drop

Lifts per Year	Crane Drop per Lift	HEPA Filtration	Container Breached Frequency (per Year)
N_{Cask}	F_{Drop}	L_filter_WHB	F_{4G-1}



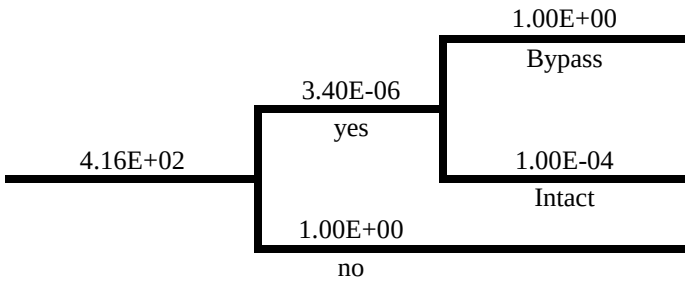
Total Frequency **7.07E-04**

LEGEND:
NR: No Release
ESR: Extremely Small Release
SR: Small Release
WCR: Worst Case Release

Figure D-6, Event Tree for NC3-B Dropped Object on Waste Material Outside Hot Cell

5BD-1 Drum Carriage Lifting Fixture Drop

Lifts per Year	Crane Drop per Lift	HEPA Filtration	Container Breached Frequency (per Year)
$N_{Carriage}$	F_{Drop}	L_filter_WHB	F_{5BD-1}



1.00E+00	1.41E-03	**WCR**
1.00E-04	1.41E-07	**ESR**
1.00E+00	None	**NR**
Total Frequency	**1.41E-03**	

LEGEND:

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

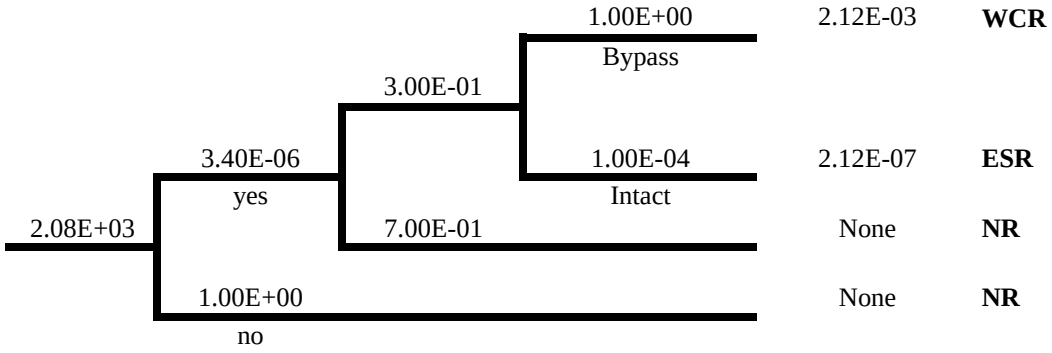
Table D-10, NC3-C - Dropped Drum or Canister in Hot Cell

Variable Name	Description	Formula	Resulting value	Comments
F10B-1	The frequency of having a drum lid come off during lifting, resulting in the drum being dropped.	NDrums * FDrop * FDrum Fail	2.12E-03	The frequency of this event is a function of the number of waste drums that are processed each year and the probability of dropping a drum while lifting it to be placed into a facility canister.
NDrums	Bounding number of RH waste drums transferred into a facility canister per year	NDrums	2.08E+03	Based on current estimated throughput.
FDrop	The probability of a crane drop per lift	FDrop	3.40E-06	Due to all mechanisms (i. e., equipment failure and human error). Per DOE/WIPP-95-2065, Rev 4
FDrum Fail	The probability that a drum is failed by a drop in the Hot Cell	FDrum Fail	3.00E-01	Per DOE/WIPP-95-2065, Rev 4, the probability that one drum in a seven pack that is dropped ten feet fails is given as 0.62. However, this probability includes the crushing effect of the other drums in the package. Since in this case a single drum is dropped, the probability of failure would be lower and is assumed to be 0.3, half the probability from the given reference.
F11F-1	The frequency of dropping a loaded facility canister in the Hot Cell while being lifted in preparation for placing it in a facility cask.	NCanisters * FDrop *	2.36E-03	The frequency of this event is a function of the number of facility canisters that are processed through the Hot Cell each year and the probability of dropping a canister while lifting it to be placed into the facility cask.
NCanisters	The total number of canisters handled per year	NCanisters	6.93E+02	Since there are three waste drums per canister, the total number of canisters handled per year is 2080/3 or 693 canisters
L_filter_WHB	Likelihood the on-line HEPA filter is open or bypassed, given a release of TRU waste in the WHB, and is therefore unavailable to accomplish its function. (Primary cause is human error that leaves the HEPA filter in an undetected bypassed condition)	1.00E-04	/event	This condition requires alignment error at the filter and lack of monitoring by the CMRO. Given the HEPA filter is required to be on-line and the delta-p across the HEPA filter is monitored in the CMR, the estimate is judged to be conservative.

Figure D-7, NC3-C Dropped Drum or Canister in Hot Cell

10BF-1 Crane Drops Drum

Lifts per Year	Crane Drop per Lift	Drum Failure from Impact	HEPA Filtration	Container Breached Frequency (per Year)
N_{Drums}	F_{Drop}	$F_{Drum\ Fail}$	L_filter_WHB	F_{10FB-1}



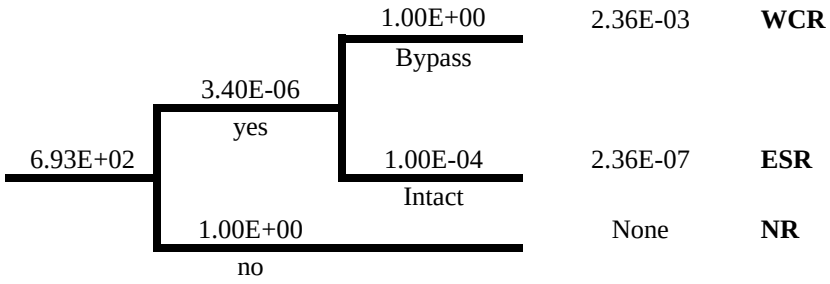
2.12E-03	**WCR**	
2.12E-07	**ESR**	
None	**NR**	
None	**NR**	
Total Frequency	**2.12E-03**	

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

Figure D-7, NC3-C Dropped Drum or Canister in Hot Cell

11F-1 Crane Drops Loaded Canister

Lifts per Year	Crane Drop per Lift	HEPA Filtration	Container Breached Frequency (per Year)
$N_{Canisters}$	F_{Drop}	L_filter_WHB	F_{11F-1}



Total Frequency **2.36E-03**

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

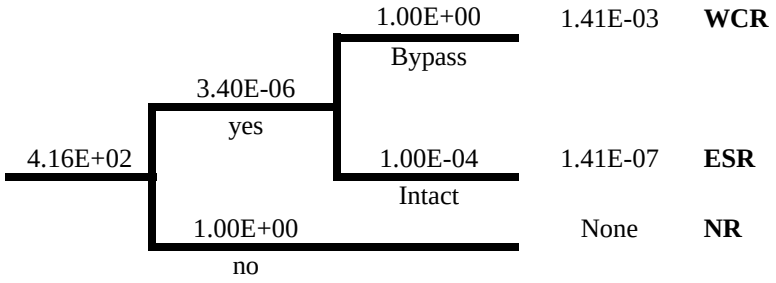
Table D-11, NC3-D - Dropped Drum or Canister Outside Hot Cell

Variable Name	Description	Formula	Resulting value	Comments
F5CE-1	The frequency of dropping a loaded drum carriage in the CUR while removing the carriage from a 10-160B Cask.	NCarriage * FDrop	1.41E-03	The frequency of this event is a function of the number of waste drum carriages that are processed through the Hot Cell each year and the probability of dropping the drum carriage while lifting it from the 10-160B Cask.
NCarriage	Number of drum carriages lifted per year	NCarriage	4.16E+02	There are two drum carriages in each 10-160B road cask. Therefore, if 208 10-160B casks are processed each year, 416 drum carriages will be lifted
FDrop	The probability of a crane drop per lift	FDrop	3.40E-06	Due to all mechanisms (i. e., equipment failure and human error). Per DOE/WIPP-95-2065, Rev 4
F12E-1	The frequency of dropping a loaded WIPP Canister into the Transfer Cell while being lifted in preparation for placing it in a facility cask.	NCanisters * FDrop	2.36E-03	The frequency of this event is a function of the number of facility canisters that are processed through the Hot Cell each year and the probability of dropping the canister.
NCanisters	The total number of canisters handled per year	NCanisters	6.93E+02	Since there are three waste drums per canister, the total number of canisters handled per year is 2080/3 or 693 canisters
L_filter_WHB	Likelihood the on-line HEPA filter is open or bypassed, given a release of TRU waste in the WHB, and is therefore unavailable to accomplish its function. (Primary cause is human error that leaves the HEPA filter in an undetected bypassed condition)	1.00E-04	/event	This condition requires alignment error at the filter and lack of monitoring by the CMRO. Given the HEPA filter is required to be on-line and the delta-p across the HEPA filter is monitored in the CMR, the estimate is judged to be conservative.

Figure D-8, NC3-D Dropped Drum or Canister Outside Hot Cell

5CE-1 Crane Drops Loaded Drum Carriage

Lifts per Year	Crane Drop per Lift	HEPA Filtration	Container Breached Frequency (per Year)
$N_{Carriage}$	F_{Drop}	L_filter_WHB	F_{5CE-1}



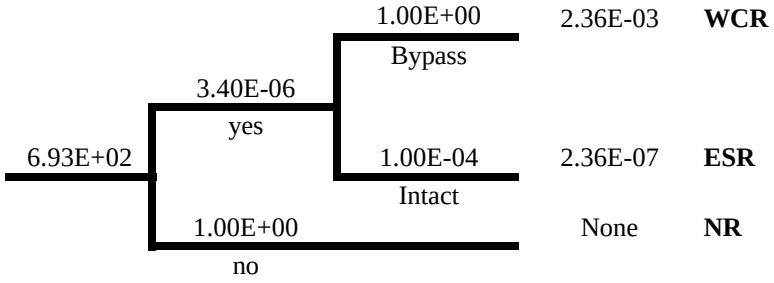
Total Frequency **1.41E-03**

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

Figure D-8, NC3-D Dropped Drum or Canister Outside Hot Cell

12E-1 Crane Drops Loaded Canister

Lifts per Year	Crane Drop per Lift	HEPA Filtration	Container Breached Frequency (per Year)
$N_{Canisters}$	F_{Drop}	L_filter_WHB	F_{12E-1}



Total Frequency **2.36E-03**

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

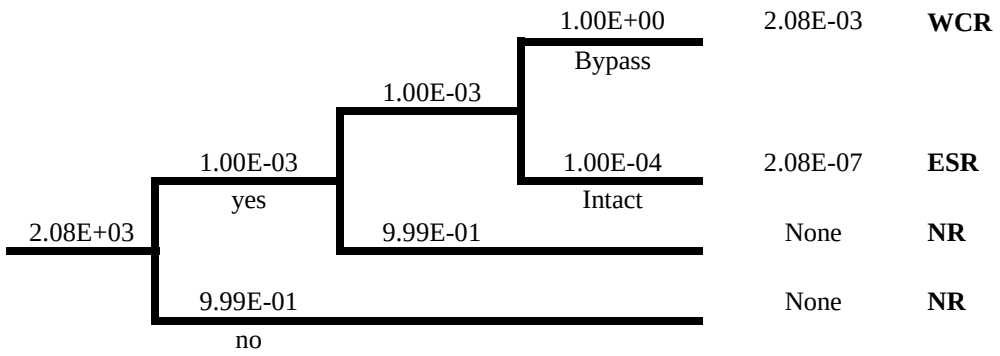
Table D-12, NC3-E - Puncture of Drum or Canister in Hot Cell

Variable Name	Description	Formula	Resulting value	Comments
F10A-1	The frequency of puncturing a waste drum or facility canister by the PAR manipulator during handling operations to place the drum in a WIPP Canister for disposal.	NDrums * FDrum Fail * FStrike	2.08E-03	The frequency of this event is a function of the number of waste drums handled using the PAR manipulator per year, the probibility of an error by the operator while using the PAR manipulator shch that the arm strikes a waste drum, and the probability that the drum is ruptured or pierced given that it is struck by the arm.
NDrums	Bounding number of RH waste drums transferred into a facility canister per year	NDrums	2.08E+03	Based on current estimated throughput.
FDrum Fail	The probability that a drum is failed by a drop in the Hot Cell	FDrum Fail	1.00E-03	Per DOE/WIPP-95-2065, Rev 4, the probability that one drum in a seven pack that is dropped ten feet fails is given as 0.62. However, this probability includes the crushing effect of the other drums in the package. Since in this case a single drum is dropped, the probability of failure would be lower and is assumed to be 0.3, half the probability from the given reference.
FStrike	The frequency of striking the drum the the PAR manipulator arm.	FStrike	1.00E-03	This event is equivalent to the failure to follow a clear, unambiguous procedure.
L_filter_WHB	Likelihood the on-line HEPA filter is open or bypassed, given a release of TRU waste in the WHB, and is therefore unavailable to accomplish its function. (Primary cause is human error that leaves the HEPA filter in an undetected bypassed condition)	1.00E-04	/event	This condition requires alignment error at the filter and lack of monitoring by the CMRO. Given the HEPA filter is required to be on-line and the delta-p across the HEPA filter is monitored in the CMR, the estimate is judged to be conservative.

Figure D-9, NC3-E Puncture of Drum or Canister in Hot Cell

10A-1 Puncture of Drum

Operations per Year	PAR Manipulator Strikes Drum (Operator Error)	Drum Failure from Impact	HEPA Filtration	Container Breached Frequency (per Year)
N_{Drums}	F_{Strike}	$F_{Drum\ Fail}$	L_filter_WHB	F_{10A-1}



Total Frequency **2.08E-03**

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

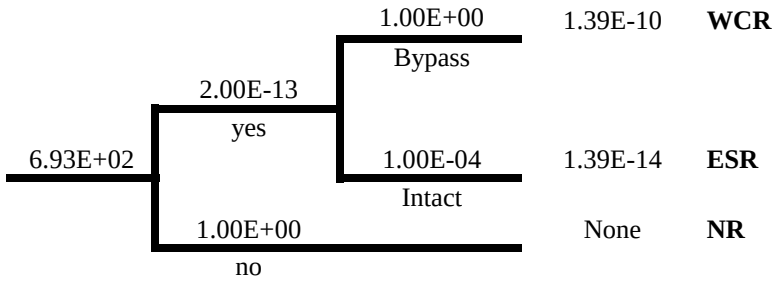
Table D-13, NC3-F Puncture of Drum or Canister Outside Hot Cell

Variable Name	Description	Formula	Resulting value	Comments
F12E-2	The frequency of puncturing a facility canister by the Hot Cell shield valve closing while a canister is being transferred.	NCanisters * FClosing	1.39E-10	The frequency of this event is a function of the number of facility canisters processed through the Hot Cell in a year and the probibility of spurious movement of the shuttle car during placement of the canister.
NCanisters	The total number of canisters handled per year	NCanisters	6.93E+02	Since there are three waste drums per canister, the total number of canisters handled per year is 2080/3 or 693 canisters
FClosing	The probability of a shield valve closing on the canister.	FClosing	2.00E-13	Per PLG 1317.
F12E-3	The frequency of inadvertent crane movement while transfering a WIPP Canister from the Hot Cell to the Transfer Cell	FCrane * FDrum Rupture * NCanisters	1.39E-03	The frequency of this event is a function of the number of facility canisters processed through the Hot Cell in a year and the probability of spurious movement of the crane during placement of the canister and the probability that the resulting impact rupures the canister.
FDrum Rupture	The probability of rupturing a facility canister.	FDrum Rupture	2.00E-03	EANL/EAD/TM-29 provides estimates of the conditional probability of rupture of a waste drum due to impact during waste handling operations. Since a facility canister is more robust than a waste drum, it is expected that it would be less likely to suffer rupture from an impact than a waste drum would.
FCrane	The probability of suprious movement of the crane	FCrane	1.00E-03	The spurious movement of the crane during transfer of a facility canister could be the result of either human error or equipment failure. However, EEG 74 indicates that 90 to 95% of all crane incidents are caused by operator error. Therefore, for this analysis it is assumed that the spurious movement of the crane is due to an operator error.
F12E-4	The frequency of inadvertent movement of the shuttle car in the Transfer Cell while a facility canister is being lowered into the facilty cask.	NCanisters * FShutt Car Mov	2.29E-09	The frequency of this event is a function of the number of facility canisters processed through the Hot Cell in a year and the probability of spurious movement of the shuttle car during placement of the canister.
FShutt Car Mov	The probability of suprious movement of the Shuttle Car	FShutt Car Mov	3.30E-12	PLG-1317, Waste Isolation Pilot Plant 6.25 Grapple Hoist Fault Tree Analysis
L_filter_WHB	Likelihood the on-line HEPA filter is open or bypassed, given a release of TRU waste in the WHB, and is therefore unavailable to accomplish its function. (Primary cause is human error that leaves the HEPA filter in an undetected bypassed condition)	L_filter_WHB	1.00E-04	This condition requires alignment error at the filter and lack of monitoring by the CMRO. Given the HEPA filter is required to be on-line and the delta-p across the HEPA filter is monitored in the CMR, the estimate is judged to be conservative.

Figure D-10, NC3-F Puncture of Drum or Canister Outside Hot Cell

12E-2 Canister Puncture by Spurious Shield Valve Closing

Transfers per Year	Spurious Shield Closing on Canister	HEPA Filtration	Container Breached Frequency (per Year)
$N_{Canisters}$	$F_{Closing}$	L_filter_WHB	F_{12E-2}



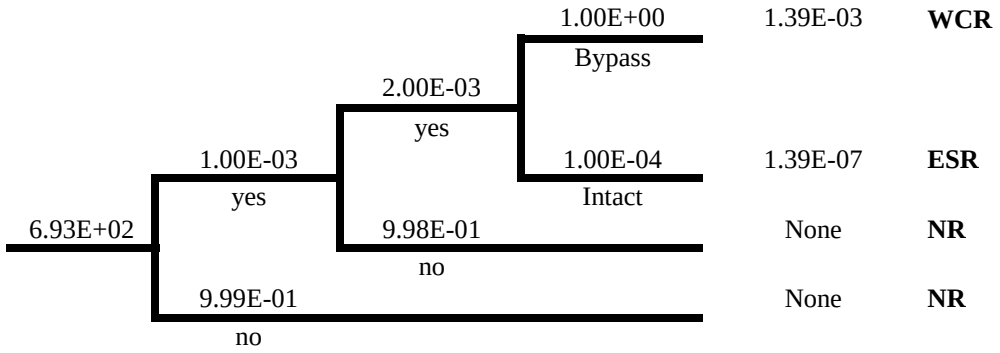
Total Frequency **1.39E-10**

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

Figure D-10, NC3-F Puncture of Drum or Canister Outside Hot Cell

12E-3 Canister Puncture by Spurious Crane Movement

Transfers per Year	Spurious Crane Movement (Operator Error)	Drum Rupture from Impact	HEPA Filtration	Container Breached Frequency (per Year)
$N_{Canisters}$	F_{Crane}	$F_{Drum\ Rupture}$	L_filter_WHB	F_{12E-3}



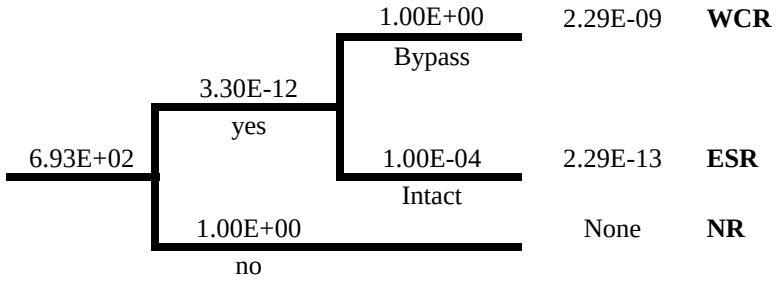
Total Frequency **1.39E-03**

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

Figure D-10, NC3-F Puncture of Drum or Canister Outside Hot Cell

12E-4 Canister Puncture by Spurious Shuttle Car Movement

Lifts per Year	Spurious Shuttle Car Movement During Lift	HEPA Filtration	Container Breached Frequency (per Year)
$N_{Canisters}$	$F_{Shutt\ Car\ Mov}$	L_filter_WHB	F_{12E-4}



2.29E-09	**WCR**	
2.29E-13	**ESR**	
None	**NR**	
2.29E-09		

Total Frequency

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

Table D-14, NC3-G Puncture of 10-160B Road Cask in RH Bay

Variable Name	Description	Formula	Resulting value	Comments
NBottles	The maximum number of compressed gas cylindes that will be moved in the RH bay in one year.	NBottles	1.60E+01	There are 2 compressed gas bottles in the RH Bay at a time, it is assummed that the cylinders will be changed out 4 times per year, there would be 8 opportunities for this event to occur. For conservatism, 16 cylinders are assumed to be moved in the RH Bay per year.
FDrum Rupture	The probability of a gas cylinder breaching a drum in a . 10-160B cask.	FDrum Rupture	1.00E-02	This a conditional probability for a drum inside the cask to be damaged and release its contents.
FGas Btl Moved	The probability of a gas cylinder movement (operator error) with a 10-160B cask is in the RH Bay	FGas Btl Moved	1.00E-04	Per DOE/WIPP-95-2065, Rev 4, this can be equated to the probability of a human errer in failing to properly follow procedures and the failure of a checker (not independent in time) to detect the error.
FCask Hit	The probability of the random direction of the gas cylinder missile hitting the cask.	FCask Hit	1.40E-02	Per DOE/WIPP-95-2065, Rev 4
FMissile	The probability for a gas cylinder to fall and become a missile	FMissile	2.00E-02	It is conservatively assumed that this sequence of events has a conditional probability. Because of the round shape and robustness of the Type B Shipping Cask, the missile must make a head-on strike of the cask.
L_filter_WHB	Likelihood the on-line HEPA filter is open or bypassed, given a release of TRU waste in the WHB, and is therefore unavailable to accomplish its function. (Primary cause is human error that leaves the HEPA filter in an undetected bypassed condition)	1.00E-04	/event	This condition requires alignment error at the filter and lack of monitoring by the CMRO. Given the HEPA filter is required to be on-line and the delta-p across the HEPA filter is monitored in the CMR, the estimate is judged to be conservative.

Figure D-11, NC3-G Puncture of 10-160B Road Cask in RH Bay

1B-6 Puncture of 10-160B Road Cask by Compressed Gas Cylinder

Gas Cylinder Transfers per Year	Gas Cylinder Movement (Operator Error)	Gas cylinder dropped, becomes missile	Gas cylinder strikes Cask	Release from Drums	HEPA Filtration	Cask breached (per Year)	
$N_{Bottles}$	$F_{Gas\ Btl\ Moved}$	F_{Missle}	$F_{Cask\ Hit}$	$F_{Drum\ Rupture}$	L_filter_WHB	F_{1B-6}	
					1.00E+00 Bypass	4.48E-09	**WCR**
				1.00E-02 yes			
			1.40E-02 yes		1.00E-04 Intact	4.48E-13	**ESR**
		2.00E-02 yes		9.90E-01 no		None	**NR**
	1.00E-04 yes		9.86E-01 no			None	**NR**
1.60E+01		9.80E-01 no				None	**NR**
	1.00E+00 no					None	**NR**
				Total Frequency		**4.48E-09**	

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

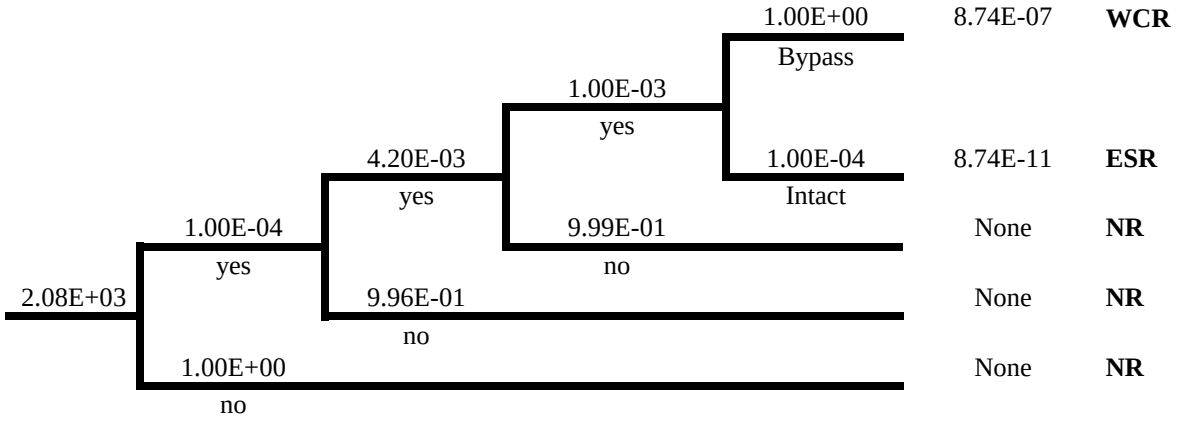
Table D-15, NC5 Explosion followed by Fire in Hot Cell

Variable Name	Description	Formula	Resulting value	Comments
F9-2	The frequency of an explosion followed by a fire in the Hot Cell	NDrums F Exp Mix L_oxidant F Ignition (OE)	8.74E-07	This frequency is a function of having an explosive gas mixture in the drum, sufficient oxidant to supporat a sustained fire and having an ignition source.
NDrums	Bounding number of RH waste drums transferred into a facility canister per year	NDrums	2.08E+03	Based on current estimated throughput.
F Exp Mix	Probability of explosive gas mixture in drum	F Exp Mix	1.00E-04	The probability of having an explosive gas mixture in a waste drum can be equated to a human error in failing to properly follow procedures in the preparation of the drum for shipment to WIPP. Per DOE/WIPP-95-2065, Rev 4
L_oxidant	The probability that there is sufficient oxidant in a waste drum to support a sustained fire	L_oxidant	4.20E-03	Per DOE/WIPP-95-2065, Rev 4
F Ignition (OE)	The probability of generating a spark that ignites the flammable gas in a waste drum	F Ignition (OE)	1.00E-03	Per DOE/WIPP-95-2065, Rev 4, this can be equated to the probability of a human errer in failing to properly follow procedures.
F11D-2	The frequency of an explosion in the Hot Cell **WELDER REMOVED**	NCanisters F Exp Mix Can L_oxidant F Ignition (Weld)	0.00E+00	This frequency is a function of having an explosive gas mixture in a drum, sufficient oxidant to supporat a sustained fire and having an ignition source.
NCanisters	The total number of canisters handled per year	NCanisters	6.93E+02	Since there are three waste drums per canister, the total number of canisters handled per year is 2080/3 or 693 canisters
F Exp Mix Can	Probability of explosive gas mixture in drum in a facility canister **WELDER REMOVED**	F Exp Mix Can	3.00E-04	Since there are three waste drums in each facility canister at the time a facility canister lid is welded, the probability that there is a waste drum with an explosive gas mixture in the canister at the time of welding is 3 times the probability of having an explosive gas mixture in a waste drum.
F Ignition (Weld)	The probability of generating a spark that ignites the flammable gas in a waste drum during welding **WELDER REMOVED**	F Ignition (Weld)	0.00E+00	The probability of a spark being created during welding of a facility canister lid in the Hot Cell would require either a human error (i. e., failure to follow proper procedures) or equipment failure (i. e., failure of the robotic welder).
L_filter_WHB	Likelihood the on-line HEPA filter is open or bypassed, given a release of TRU waste in the WHB, and is therefore unavailable to accomplish its function. (Primary cause is human error that leaves the HEPA filter in an undetected bypassed condition)	1.00E-04	/event	This condition requires alignment error at the filter and lack of monitoring by the CMRO. Given the HEPA filter is required to be on-line and the delta-p across the HEPA filter is monitored in the CMR, the estimate is judged to be conservative.

Figure D-12, NC5 Explosion followed by Fire in Hot Cell

Explosion/Fire in Hot Cell (9-2)

Drums per Year	Explosive Gas in Drum	Sufficient Oxidant in Drum	Ignition Source (Operator Error)	HEPA Filtration	Drum Breach Frequency (per Year)
N_{Drums}	$F_{Exp\ Mix}$	L_oxidant	$F_{Ignition(OE)}$	L_filter_WHB	F_{9-2}



Total Frequency **8.74E-07**

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

Figure D-12, NC5 Explosion followed by Fire in Hot Cell

Explosion in Hot Cell (11D-2)

Canister per Year	Explosive Gas in Canister	Sufficient Oxidant in Drum	Ignition Source (Welding) **welder removed**	HEPA Filtration	Canister Breach Frequency (per Year)	
$N_{Canisters}$	$F_{Exp\ Mix\ Can}$	L_oxidant	$F_{Ignition(Weld)}$	L_filter_WHB	F_{11D-2}	
				1.00E+00 Bypass	0.00E+00	**NR**
			0.00E+00 yes			
		4.20E-03 yes		1.00E-04 Intact	0.00E+00	**NR**
	3.00E-04 yes		1.00E+00 no		None	**NR**
6.93E+02		9.96E-01 no			None	**NR**
	1.00E+00 no				None	**NR**
			Total Frequency		**0.00E+00**	

NR: **No Release**
ESR: **Extremely Small Release**
SR: **Small Release**
WCR: **Worst Case Release**

REFERENCES

1. DOE/WIPP-96-2196, Waste Isolation Pilot Plant, TRUPACT Crane System Analysis, September 1996.

2. WSRC-TR-93-262, "Savannah River Site Generic Data Base Development (U), Savannah River Site, Aiken, SC.

3. INEL-94/0226, Rev.3, Radioactive Waste management Complex Safety Analysis Report, Idaho National Engineering and Environmental laboratory, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho 83415

4. DOE/WIPP 95-2065, Rev.2, Waste Isolation Pilot Plant Safety Analysis Report, Waste Isolation Pilot Plant, Carlsbad, N.M.

5. WSRC-TR-93-581,"Savannah River Site Human Error Data Base Development For Nonreactor Nuclear Facilities (U)", Savannah River Site, Aiken, SC.

6. DOE/WIPP 87-005, Waste Drum Fire Propagation at the WIPP, April 1987

7. 1997 Motor Vehicle Crash Date From FARS and GES, Traffic Safety Facts, TABLE 38, Department of Transportation

8. WIPP/WID-96-2178, WIPP Hoist Brake System Analysis, July 1996.

9. Post-Seismic Fire Probability for the Consolidated Tritium Facility (U), F-CLC-H-00012, Rev. 0, Westinghouse Savannah River Company, Savannah River Site, Aiken, S.C., March 1996.

10. SMRP No. 155, "A Site-Specific Study of Wind and Tornado Probabilities at the WIPP Site in Southeast New Mexico," Department of Geophysical Sciences, T. Fujita, University of Chicago, February 1978 and its Supplement of August 1978.

This page intentionally blank