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PNNL-20173 Rev. 1

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Air Dispersion Modeling of Radioactive Releases During Proposed PFP Complex Demolition Activities

Report to CH2M HILL Plateau Remediation Company

BA Napier
JP Rishel

December 2015

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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

This report is part of the planning process for the demolition of the 234-5Z, 236-Z, 242-Z, 291-Z, and 291-Z-1 structures at the Plutonium Finishing Plant (PFP) on the Hanford Site. Pacific Northwest National Laboratory (PNNL) supports the U.S. Department of Energy (DOE) and the CH2M HILL Plateau Remediation Company (CHPRC) demolition planning effort by making engineering estimates of potential releases for various potential demolition alternatives. This report documents an analysis considering open-air demolition using standard techniques. It does not document any decisions about the decommissioning approaches.

Atmospheric dispersion modeling using estimated release rates has been conducted to provide information on the location and levels of radioactive contamination that may be expected as the result of demolition activities. The close proximity of the PFP facilities to each other has the potential to affect dispersion patterns through various meteorological phenomena, including building wake effects. Hourly meteorological data collected over a 6-year period (2004–2009) were used to examine the effects of wind speed, direction, and stability on projected concentrations of contaminants in air and deposited on nearby surfaces.

The radioactive contamination of concern for the PFP complex is largely transuranic contamination from past operations. Operations are underway to remove a large fraction of this contamination. The source terms modeled in this report are based on the residual contamination levels that are anticipated for the various structures at the time of demolition.

The radiological consequences have been established using the five-factor formula considering material-at-risk, damage ratio, airborne release fraction, respirable fraction, and leak path factor. Radioactive contamination emissions have been calculated by release mechanism and demolition area for on-shift and off-shift activities. The emissions from the applicable sources have been combined to provide emissions estimates for each day from each demolition area.

The U.S. Environmental Protection Agency's (EPA's) AERMOD computer code is used to estimate atmospheric dispersion and deposition of the released radioactive materials in the immediate vicinity of the demolition activities. The modeling is conducted to be fully representative of the range of the weather conditions that are possible (i.e., uses multiple full annual cycles of meteorological data) and representative of the expected demolition period (i.e., models the hours of the day that demolition activities will occur). The modeling also includes the effects of local building structures on the near-filed atmospheric dispersion rates.

Both airborne and surface concentrations are modeled with AERMOD. Hourly derived air concentrations (DAC) are modeled for an array of receptors covering the demolition site and surrounding area. Peak (95^{th} percentile) values of time-integrated air concentrations at these receptor points are derived from these hourly values, with modeling results reported as total incremental air concentrations in DAC-hours occurring over the selected time period. Total accumulated deposition amounts are evaluated with AERMOD using the same array of receptors, with results reported as dpm per 100 cm^2.

Each building in the PFP complex is considered in terms of its construction and suggested target contamination levels. The modeling effort is conducted based on the assumed sequence of the demolition scenarios. The results in this report are based on the following demolition scenarios:

- The preferred option assumed is to entirely demolish 236-Z with hydraulic shears or mechanical hammer. That activity is projected to require about 39 working days over about 10 weeks of elapsed time. Several highly-contaminated gloveboxes and galleries will be carefully removed as access is available. A connecting wall with 242-Z would remain.
- The 242-Z building roof and walls are assumed to be demolished with a multiprocessor that operates hydraulic shears or mechanical hammer end effectors. Contaminated tanks would be carefully removed during demolition. It was assumed that the overall demolition would require about 7 days over a two-week period. A connecting wall with 234-5Z would remain.
- The various zones of the 234-5Z building are assumed to be demolished using hydraulic shears or mechanical hammer. Certain gloveboxes, ductwork, and piping may remain in the building until the time of demolition; they would be carefully removed as access is available. The entire demolition process for 234-5Z is assumed to require 68 days over a period of about 17 weeks.
- The above-ground portions of the 291-Z fan house will be removed using hydraulic shears or mechanical hammer. Contaminated vacuum lines would be cut and capped prior to demolition and removed as access is available. The demolition is assumed to require 18 days over a period of about 5 weeks.
- The 291-Z-1 stack is assumed to be toppled with explosives; the stack will be directed to fall onto the ground or into a prepared shallow trench. After being toppled, the stack will be broken up into smaller pieces and removed using a multiprocessor. The entire process is assumed to require 15 days over a period of 4 weeks.

All demolition scenarios incorporate some realistic assumptions about release mitigation; use of fixatives and misting/spraying is included in all release estimates. Work is assumed to be performed during 10-hour day and swing shifts, with a preference for demolition during the days and rubble removal during swing shifts.

The exposure results from demolition of the 234-5Z, 242-Z, and 291-Z structures and the 291-Z-1 stack are presented as a local-area map of potential exposures from demolition activities. The climatologically-based patterns of predicted weekly air exposure 95th percentile values (expressed as weekly total DAC-hours) for these PFP structures are plotted in Figure S.1. The results are based on the highest projected emission rates related to the demolition of the RMA/RMC lines. This plot presents a composite of the maximums of 95th percentile exposure values on the area surrounding the demolition activity based on all the modeled total work-week exposures. The total work-week exposures are based on the total exposures for all the contiguous 4-day periods occurring in the 6 years of meteorological observations. All other demolition activities associated with demolition activities for these buildings will have lower levels of predicted weekly peak exposures.

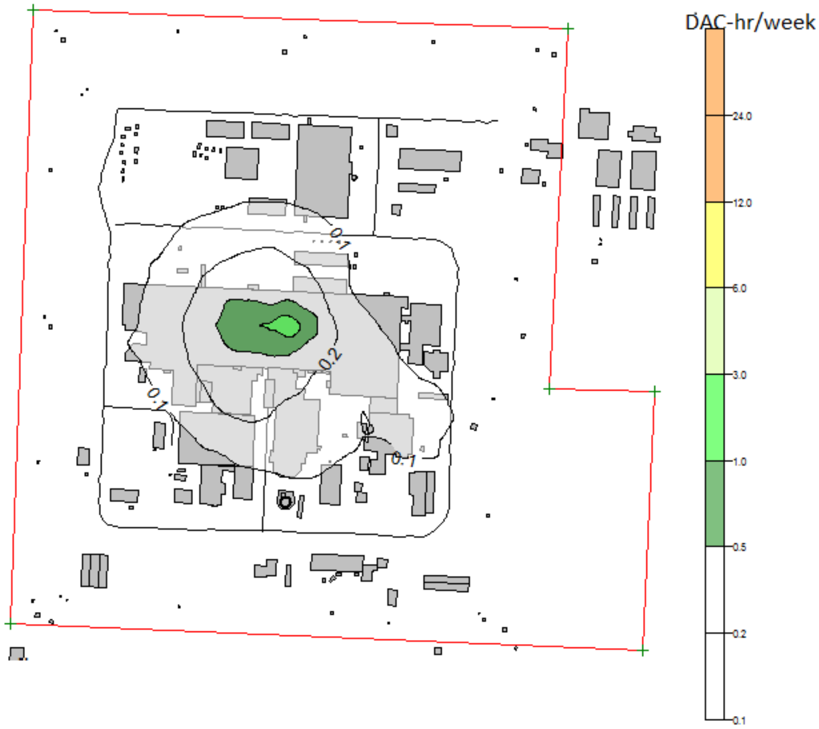

Figure S.1.Weekly Air Exposure 95th Percentile for Demolition of 234-5Z, 242-Z,291-Z, and 291-Z-1

The highest 95th percentile air exposure modeling results for the demolition of the 236-Z cell and associated buildings with shears or mechanical hammer are presented in Figure S.2. These structures include areas with the highest contamination levels in the PFP complex. Because the activity weighted emissions from the 236-Z cell alone account for 98% of the projected emissions from demolition of the 236-Z cell and associated buildings combined, the results given below are fully attributable to the demolition activities for the 236-Z cell alone. This figure indicates that there is at least a 95 percent probability that the Hanford Site administrative limits can be met during the demolition of the 236-Z facility.

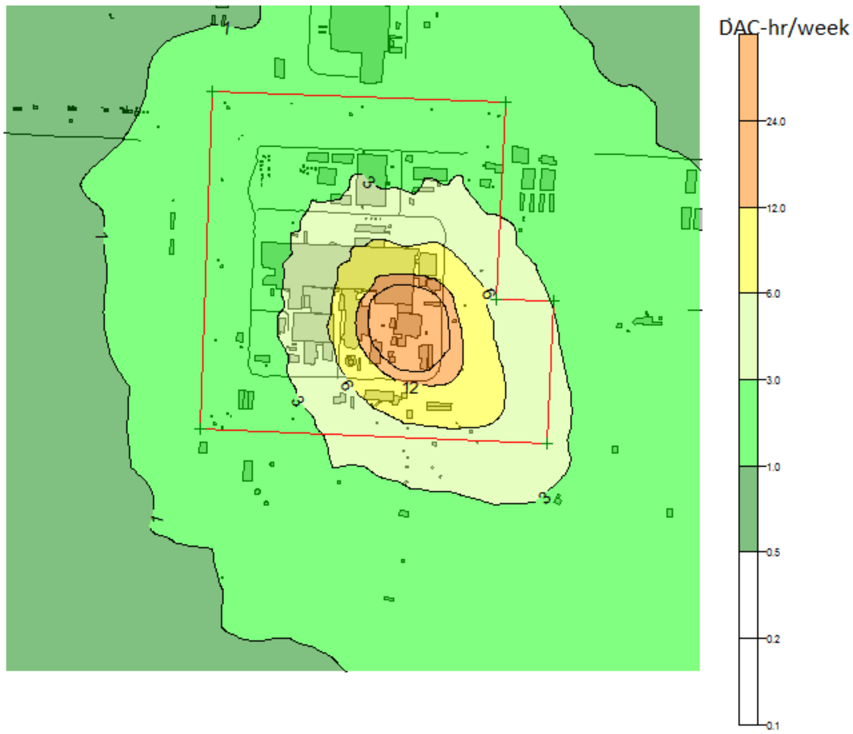

Figure S.2. Predicted Weekly Air Exposure 95th Percentile Values for 236-Z Demolition

The analysis shows that some releases of radioactive material are to be anticipated during the demolition of the PFP structures. The modeling results presented here are closely tied to the details of how the demolition is to be conducted. The results indicate that for the bulk of the PFP facilities, including the PFP stack, the radiological exposures from the planned demolition efforts will be well below the designated limits for air and soil exposures. However, the demolition of the 236-Z main process cell will release some alpha-emitting radionuclides; the worst case in all 6-years' worth of data indicate that concentrations at the fenceline of the PFP facilities could under certain conditions approach a value of 12 DAC-hours/week .

Acknowledgments

The authors would like to extend their appreciation to Brian Oldfield and Peter Sauer of the CH2M HILL Plateau Remediation Company for financial and technical support of this work. Meteorological data from the Hanford Meteorological Station for the period was provided by Ken Burk, Pacific Northwest National Laboratory. This work was funded by CH2M HILL Plateau Remediation Company under the U.S. Department of Energy Contract DE-AC05-76RL01830.

Acronyms and Abbreviations

AED	aerodynamic equivalent diameter
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
ARF	airborne release fraction
Bq	becquerel
BPIP	Building Profile Input Program (AERMOD preprocessor program)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHPRC	CH2M HILL Plateau Remediation Company
Ci	curie(s)
cm	centimeter(s)
DAC	derived air concentration
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DR	damage ratio
EF	emission factor
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ft	foot (feet)
g	gram
HEPA	high-efficiency particulate air (filter)
HMS	Hanford Meteorological Station
in.	inch(es)
lb	pound(s)
LPF	leak path factor
m	meter(s)
MAR	material-at-risk
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
PRF	Plutonium Reclamation Facility (236-Z Building)
PRIME	AERMOD Plume Rise Model
Pu	plutonium
RF	respirable fraction
RMA	Remote Mechanical "A" process line
RMC	Remote Mechanical "C" process line
ST	source term
TRU	Transuranic (comprised of elements with higher atomic number than uranium)

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1.0 Introduction

The Hanford Plutonium Finishing Plant (PFP), located in the 200 West Area, converted plutonium-bearing chemical solutions to metals and oxides until 1989. The current mission of the PFP requires deactivating and dismantling PFP complex systems and structures to the degree determined appropriate by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process, thus eliminating significant hazard to workers, the public, and the environment and minimizing long-term surveillance and maintenance risks and costs. U.S. Department of Energy (DOE) and CH2M HILL Plateau Remediation Company (CHPRC) plans call for eventual demolition of many of the PFP structures.

Pacific Northwest National Laboratory (PNNL) supports the demolition planning effort by making engineering estimates of potential releases for various potential demolition alternatives. Atmospheric dispersion modeling has been conducted using those release rates to provide information on the location and levels of radioactivity. This report documents an analysis considering open-air demolition using standard techniques. It does not document any decisions about the decommissioning approaches.

This report is part of the planning process for the demolition of the 234-5Z, 236-Z, 242-Z, and 291-Z-1 structures at the PFP complex; these structures are highlighted in blue in Figure 1.1. A number of the other structures shown in gray in the figure have been, or will be, removed before demolition of the other structures occurs.

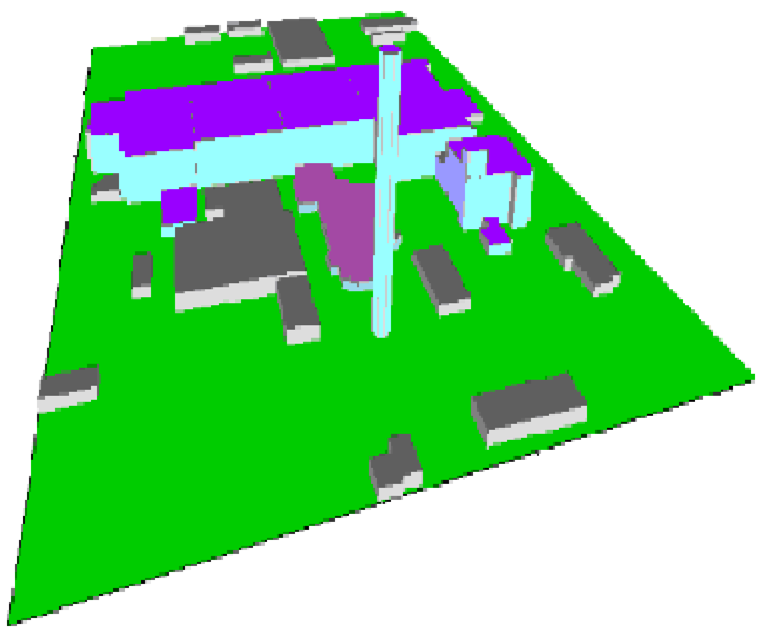

Figure 1.1. The Plutonium Finishing Plant Complex

The PFP complex shown in Figure 1.1 has many large structures that will influence the local atmospheric dispersion. These structures have the potential to affect dispersion and deposition patterns through various meteorological phenomena, including building wake effects. Atmospheric dispersion calculations have been made using the AERMOD (40 CFR 51, Appendix W) dispersion model developed by the U.S. Environmental Protection Agency (EPA). AERMOD is the EPA's recommended dispersion model for regulatory applications; the model incorporates the latest understanding of atmospheric dispersion, and it explicitly accounts for building wake effects. The results from the AERMOD calculations are being used to help plan demolition activities that will keep potential contamination within the limits established for the project contamination area and to define exclusion zones.

The 234-5Z building is approximately 152 m (500 ft) long and 55 m (180 ft) wide. The floor levels are the basement, the first floor, the duct level, and the second floor. The frame is structural steel with an outer sheathing of aluminum panels over rock wool insulation and 16-guage sheet metal. There are also 20-cm (8-in.) thick interior reinforced concrete walls, principally running in the east-west direction, and two box-type reinforced concrete stairwells. The stairwells extend to the roof; the reinforced concrete walls stop at the second floor. Contamination levels are quite variable within this large structure; the bulk of residual contamination is expected to reside in the central core and on the duct level.

The 236-Z building (also known as the Plutonium Reclamation Facility - PRF) is located south of the southeastern corner of the 234-5Z building and is connected to it by the 242-Z building. The building is a four-story structure 24 m (79 ft) by 21.6 m (71 ft) by about 14.5 m (47.5 ft) high, surmounted at the southwest corner by a two-story penthouse 6.9 m (22.5 ft) high. With the exception of the roof, the south end of the process cell, and the fourth-floor ceiling, the building is constructed of reinforced concrete. The roof is constructed of an open-web steel joist frame, a steel deck with rigid insulation of lightweight concrete fill, and gravel-covered built-up roofing. A portion of the south wall is also the 1-ft-thick wall of the process cell. An equipment transfer facility is located against the large south door. The tanks and columns used in the solvent extraction process were located in the process cell—a large three-story room in the center of the 236-Z building.

The 242-Z building (formerly known as the Waste Treatment Facility) connects the 234-5Z and 236-Z buildings. The 242-Z building is 12 m (40 ft) wide, 8 m (26 ft) long, and 7 m (23 ft) high. The south wall of the 242-Z is reinforced concrete; the remainder of the building has a structural steel frame covered with metal lath and plaster internally and insulating wall panels externally. The roof is constructed of metal decking covered with built-up asphalt and gravel. A serious accident involving an explosion of an americium separation column occurred in this building in 1976, which resulted in extensive ^{241}Am contamination inside the building.

The 291-Z building provides controlled ventilation exhaust for the 234-5Z, 242-Z, and 236-Z buildings. The 291-Z-1 reinforced concrete stack is located adjacent to the 291-Z building. The stack is 61 m (200 ft) tall.

The main report provides a description of the overall analysis approach used to evaluate the air emissions during demolition (Section 2), the local patterns of predicted incremental air concentrations and deposition rates for the major buildings and stack (Section 3), and a discussion of the results (Section 4). The appendices provide the structure-by-structure details of the source-term analysis and atmospheric dispersion modeling. The source-term appendices include the modeling scenarios, source-term inventories, and demolition options. The air dispersion appendices include modeling assumptions as well as the AERMOD input and output file listings.

2.0 Discussion of Analysis Approach

Atmospheric dispersion modeling has been conducted in support of the demolition of the Plutonium Finishing Plant (PFP) complex using estimated release rates to provide information on the location and levels of radioactive contamination that may be expected as the result of demolition activities. The close proximity of the PFP building structures to each other has the potential to affect dispersion patterns through various meteorological phenomena, including building wake effects. Hourly meteorological data collected over a 6-year period (2004–2009) was used to examine the effects of wind speed, direction, and stability on projected concentrations of contaminants in air and deposited on nearby surfaces.

The radioactive contamination of concern for the PFP complex is largely transuranic (TRU) contamination from past operations. Operations are underway to remove a large fraction of this contamination. The source terms modeled in this report are based on the residual contamination levels that are anticipated for the various structures at the time of demolition.

The radiological consequences have been established using the methods discussed in DOE-HDBK-3010-94 (DOE 1994). This approach was successfully used for the 233-S building (AlphaTRAC 2003a, 2003b), the 232-Z building (Droppo et al. 2006), the 105 KE Basin (Napier et al. 2008), and the 224-U and 224-UA buildings (Napier et al. 2009; Napier et al. 2010; Droppo et al. 2011).

2.1 Source Term Methodology

The source term may be quantified using the five-factor formula[1]

$$ST = MAR * DR * ARF * RF * LPF \qquad (2\text{-}1a)$$

$$ST = MAR * EF \qquad (2\text{-}1b)$$

where: Source term (ST) = the total quantity of respirable material released to the atmosphere during the demolition

Material-at-risk (MAR) = the total quantity of radionuclides (in grams or curies of activity for each radionuclide) available to be acted on by a given physical stress

Damage ratio (DR) = the fraction of the MAR actually impacted by the demolition conditions

Airborne release fraction (ARF) = the fraction of a radioactive material suspended in air as an aerosol and thus available for transport due to a physical stress from a specific activity

Respirable fraction (RF) = 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

Leak path factor (LPF) = the fraction of the radionuclides in the aerosol transported through some confinement system (e.g., facility rooms, ductwork), filtration mechanism (e.g., high-efficiency particulate air [HEPA] or sand filters), and emission mitigation methods (e.g., misters or foggers).

The last four factors are sometimes combined into an Emission Factor (EF) to be multiplied with the MAR, where EF = DR*ARF*RF*LPF.

[1] The following discussion is adapted from *GENII Computer Code Application Guidance for Documented Safety Analysis*, DOE-EH-4.2.1.4-Interim-GENII, Rev. 1, U.S Department of Energy, Washington, D.C.

For these analyses, the MAR is defined as the inventory that is on the surface area being demolished or within equipment remaining in the facility. While it is permissible to exclude material forms that are considered to be unaffected from the MAR, experience suggests that for these forms the DR is usually best set to zero for the release mechanism. The overall result using either approach is the same. However, by assigning DR values to each combination of inventory form and release mechanism, there is the expectation that each credited form is also reviewed against secondary events and, therefore, less likely to be overlooked.

Details of the source term analysis for each component of PFP are presented in Appendix A. Radioactive contamination emissions (STs) have been calculated by release mechanism and demolition area for on-shift and off-shift activities. The emissions from the applicable sources have been combined to provide emissions estimates for each day from each demolition area.

2.2 Air Dispersion Modeling

The U.S. Environmental Protection Agency's (EPA's) AERMOD dispersion model is used to estimate atmospheric concentration and surface deposition of the released radioactive materials in the immediate vicinity of the demolition activities. AERMOD provides hourly estimates for the time periods that demolition is planned by accounting for the ambient meteorological conditions as well as the effect of the nearby buildings on the air flow. The hourly estimates can be used to analyze longer time periods from within AERMOD or through post-processing. The rationale for the selection and use of the AERMOD dispersion model is documented in Appendix B.

The modeling is conducted to be inclusive of the weather conditions that are possible (i.e., uses full annual cycles of meteorological data) and representative of the expected demolition period (i.e., models the hours of the day that demolition activities will occur). The air concentrations and deposition rates are modeled for an array of receptors covering the demolition site and surrounding area. Weekly-averaged values of air concentrations are evaluated with modeling results reported as the 95th percentile of the time-integrated incremental derived air concentrations in DAC-hours; total estimated depositions from all activities are presented as disintegrations per minute (dpm) per 100 cm^2.

The modeling analysis defines the potential levels of air and surface exposures from the proposed demolition activities. Potential air exposures are defined in terms of 1) composite spatial patterns of average and peak concentrations and 2) the distribution of occurrences of peak (95th percentile) concentrations at measurement locations and control boundaries. The potential surface depositions are defined in terms of total deposited concentrations of alpha- and beta/gamma-emitting materials.

Using these methods, emission and air dispersion computations were made to assess the potential concentrations from different sets of demolition assumptions. The analysis process consisted of three steps:

1. Estimate the emission rates for the proposed demolition activities - Step 1 starts with an estimate of the amount of contamination in the structure, what form it is in, and where it is located. Demolition methods and associated activities are identified in this step. These data are combined to generate estimates of emissions during the demolition activities.

2. Compute the airborne and deposited concentrations - Step 2 takes the emission rate estimates from Step 1 and produces estimates of environmental concentrations. An assumed 1-hour release is used to

define potential peak exposures. The main intermediate products are 95th percentile hourly air concentrations and hourly surface deposition.

3. Determine if the potential concentration levels are acceptable - Step 3 uses standards to evaluate the viability of the demolition option that has been modeled. For air exposures, a limit of 12 DAC-hours per week is used. For deposition, a limit of 20 dpm/100 cm^2 removable alpha contamination is used. If none of the locations within the selected areas show values that exceed these limits, then the demolition is deemed clearly viable.

The potential emission rates associated with proposed demolition activities are estimated based on specific methods of execution. Appendix A provides a detailed definition of those activities including the assumptions and approximations that are required to provide a context for the demolition for each of the PFP components.

The air dispersion modeling with AERMOD requires a number of assumptions related to model options, source-term input definition, analysis products, time scales, and receptor locations. The details of those assumptions are discussed in Appendix C.

2.3 Airborne Contamination Dosimetry

The dosimetry depends on the mixture of radioisotopes present. The inventories listed in Table 2.1 are assumed to represent the contamination present in the various PFP complex buildings and equipment. The spectrum of radionuclides is based on the best information available for each structure.

U.S. Department of Energy (DOE 1998) regulations specify in 10 CFR 835.2, “Definitions,” that an airborne radioactivity area means any area accessible to individuals where the concentration of airborne radioactivity above natural background exceeds or is likely to exceed the DAC, or an individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week. If radionuclides “A,” “B,” and “C” are present in concentrations C_A, C_B, and C_C, and if the applicable DACs are DAC_A, DAC_B, and DAC_C, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{DAC_A} + \frac{C_B}{DAC_B} + \frac{C_C}{DAC_C} \leq 1 \tag{2.2}$$

For a mixture of radionuclides where the concentrations of each are expressed in terms of a fraction, f, of a total, DAC_T, this can be written as:

$$\frac{f_A \times DAC_T}{DAC_A} + \frac{f_B \times DAC_T}{DAC_B} + \frac{f_C \times DAC_T}{DAC_C} \leq 1 \tag{2.3}$$

This relationship can be used to determine a maximum total concentration that meets the requirements as:

$$\frac{f_A}{DAC_A} + \frac{f_B}{DAC_B} + \frac{f_C}{DAC_C} = \frac{1}{DAC_T} \tag{2.4}$$

2.4 Summary of Anticipated Radionuclide Inventories

Because the various buildings and rooms within each building have different anticipated contamination levels at the time of demolition, for the purposes of demolition planning the complex has been subdivided into demolition planning zones. The major zones for 234-5Z are illustrated by numbered areas in Figure 2.1. Along the top and left side of this figure, numbers 1-26 and Letters A-J represent the locations of vertical/horizontal lines whose intersection identify the locations of support columns within the 234-5Z building. The 236-Z structure location is shown; not explicitly illustrated are the 7 zones for 236-Z which are based upon the structure's six floors and canyon. Dashed lines represent the 291-Z fan house, which is connected to the 291-Z-1 stack.

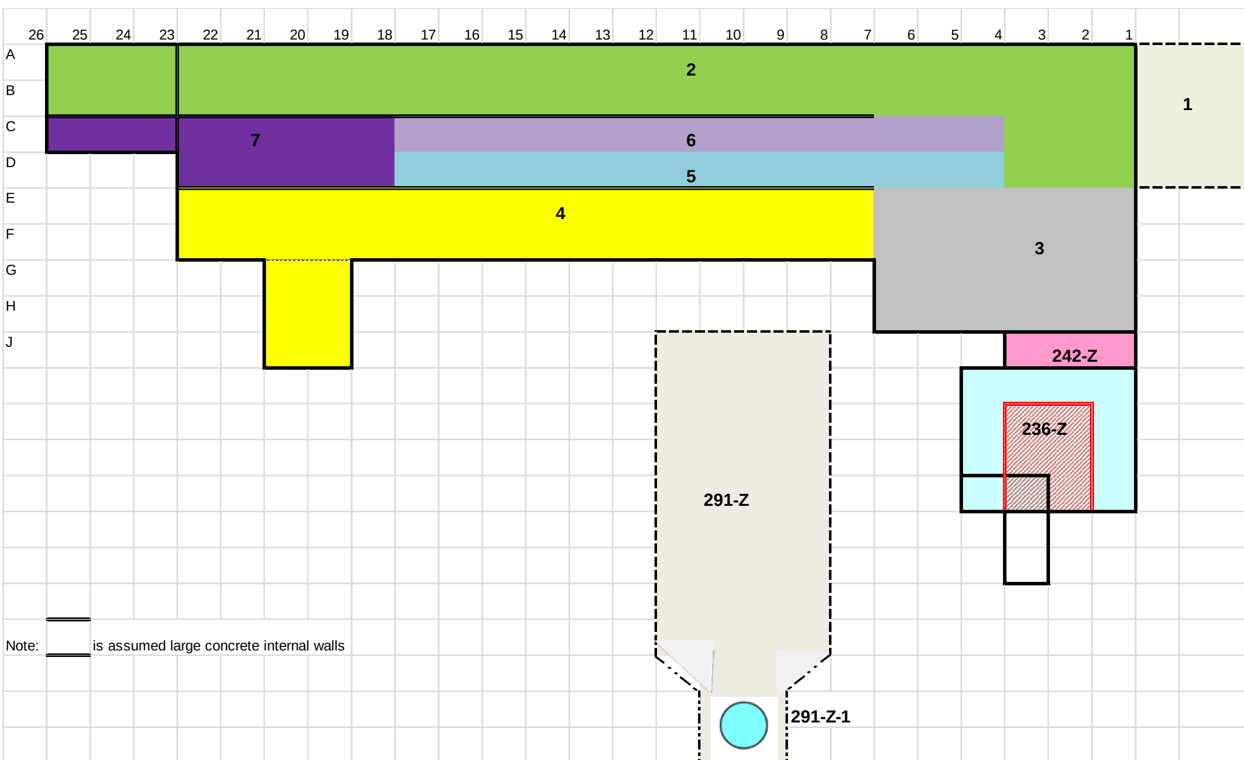

Figure 2.1. Demolition Zones Defined for this Analysis

The radioactive contamination of concern for the PFP building demolition is located on surfaces, under paint and tiles, within ducts, and in other inaccessible places. Table 2.1 is a summary of the inventories used in the structure-specific source term analyses in Appendix A. The total inventories are estimated based on the listed levels of residual contamination assumed at the time of demolition.

Table 2.1. Anticipated Inventory of Radionuclides in Defined Demolition Zones of the PFP Complex

			Contaminated Surfaces			*Strategic Removals*		
Facility	**Zone**	**Location**	**Debris Wt (lb)**	**Area (SF)**	**dpm/100cm^2**	**QTY**	**Unit**	**TRU Pu (g)**
236-Z	SZ-1	236-Z 6th Floor	193228	1216	2000	1	Glovebox	170
	SZ-2	236-Z 5th Floor	165469	1074	2000	2	GB's/FB's	137
	SZ-3	236-Z 4th Floor	1158363	7081	2000	8	Gloveboxes	973
	SZ-4	236-Z 3rd Floor	1051893	2629	2000	1	Filterbox	3
	SZ-5	236-Z 2nd Floor	1102836	3940	2000	56	Gallery GB's/FB's	584
			19750	4700	1.70E+06	312	LF Ductwork	N.A.
	SZ-6	236-Z 1st Floor	1122587	6613	2000	8	Gallery GB's/FB's	792
	SZ-7	236-Z Canyon	2064161	8305	25 nCi/g	41	Strongbacks	N.A.
			6878287	**35557**				
242-Z	SZ-1	242-Z and 242-ZA	**289446**	**9100**	4.10E+06	9	Tanks	532
					3.73E+10			
234-5Z	SZ-1	234-5ZA	262335	1000	2000	None	--	--
	SZ-2	234-5Z Front Side	5319554	10000	2000	None	--	--
	SZ-3	234-5Z A Labs	2233034	117344	20000	15	GB's/FB's	29
	SZ-4	234-5Z Backside/PPSL	3323369	196364	20000	17	GB's/FB's	553
	SZ-5	234-5Z RMA Process Line	1545479	105384	200000	9	GB's/FB's	232
			19750	2000	200000	1000	LF Ductwork	100
	SZ-6	234-5Z RMC Process Line	1676105	99908	200000	7	GB's/FB's	35
	SZ-7	234-5Z RADTU/Basement	1510281	72496	20000	6	GB's/FB's	20
			38750	Epoxy Filled		2182	LF Tunnel Drains	550
			15928658	**604495**				
291-Z	SZ-1	291-Z Fanhouse	5314936	12000	2000	724	LF 26" PV Lines	502
	SZ-2	291-Z-001 Stack	937365	9000	3000	None	--	--
			6252301	**21000**	2.70E+07			

*The notation LF denotes "linear feet" of pipes or ducting; GB indicates "Glove box" and FB indicates "Filter box"

2.5 Modeling Demolition Scenarios

The modeling analysis requires definition of representative demolition scenarios. Those scenarios include both the activities and a plan for performing those activities. The most-accessible equipment and sections of the buildings are assumed to be removed before less-accessible components. The analyses credit the use of misting, water, and fixatives throughout the demolition and load out process to minimize airborne contamination spread.

Each building in the PFP complex is considered in terms of its construction and anticipated contamination levels (see details in Appendix A). All demolition and load out will only occur when sustained wind speeds are less than 20 miles per hour. The results, which are presented in Section 3, are based on the following demolition scenarios:

- The preferred option assumed is to entirely demolish 236-Z with hydraulic shears or mechanical hammer. That activity is projected to require about 39 working days over about 10 weeks of elapsed time. Several highly-contaminated gloveboxes and galleries will be carefully removed as access is available. A connecting wall with 242-Z would remain.

- The 242-Z building roof and walls are assumed to be demolished with a multiprocessor that operates hydraulic shears or mechanical hammer end effectors. Contaminated tanks would be carefully removed. It was assumed that the overall demolition would require about 7 days over a two-week period. A connecting wall with 234-5Z would remain.
- The various zones of the 234-5Z building are assumed to be demolished using hydraulic shears or mechanical hammer. Certain gloveboxes, ductwork, and piping may remain in the building until the time of demolition; they would be carefully removed as access is available. The entire demolition process for 234-5Z is assumed to require 68 days over a period of about 17 weeks.
- The above-ground portions of the 291-Z fan house will be removed using hydraulic shears or mechanical hammer. Contaminated vacuum lines would be cut and capped prior to demolition and removed as access is made available. The demolition is assumed to require 18 days over a period of about 5 weeks.
- The 291-Z-1 stack is assumed to be toppled with explosives; the stack will be directed to fall into a prepared shallow trench. After being toppled, the stack will be broken up into smaller pieces and removed using a multiprocessor. The entire process is assumed to require 15 days over a period of 4 weeks.

The demolition scenarios assume that, even with fixatives, misting, and other controls, a certain amount of dust will escape from the demolition activities. The amount of dust released as a function of time from the start of demolition is shown in Figure 2.2. The actual radiation risk is related to the amount of residual radioactive contamination contained in the dust, which varies with the various parts of the facility being demolished. An inventory-weighted plot of the source term is shown in Figure 2.3. It can be seen in Figure 2.2 that the portion of the demolition related to demolishing the outer, low-contaminated portions of the 236-Z building has the largest continuous amount of dust released (approximately weeks 1 to 7). The modeling assumed that only moderate controls would be applied to this portion of the demolition because of the low inventory – with the exception of the removal of the highly-contaminated galleries. In Figure 2.3, it can be seen that the radioactive source term resulting from this portion of the demolition is low until the final week when the galleries are removed. The later weeks of demolition of 236-Z are relatively low in Figure 2.2, but the corresponding pattern in Figure 2.3 has a high peak. Notice that the latter portions of the demolition of 236-Z show the largest releases of radioactive material; this is the largest part of the assumed source term, caused by the assumption that the cell contamination averages 25 nCi/g of cell mass. The peak at the start of cell demolition (about week 8) results from the dust (and radioactive material) released during the demolition of the cell ceiling and dropping of the rubble to the ground.

All weeks subsequent to the removal of the 236-Z cell have radioactive emission rates 3 orders-of-magnitude or more lower than that of the cell removal period. The contamination in the remainder of the PFP facilities, including the more highly-contaminated portions of 242-Z and the 234-5Z RMA and RMC lines, is substantially lower than that of the 236-Z process cell. The dip in the curve of Figure 2.2 about week 11 is due to the relatively small amount of material at risk in the 242-Z Building tank room and annex. The substantial dip in the curve of Figure 2.3 at about weeks 13-15 is a result of the demolition of the relatively uncontaminated office spaces and front face of the 234-5Z building.

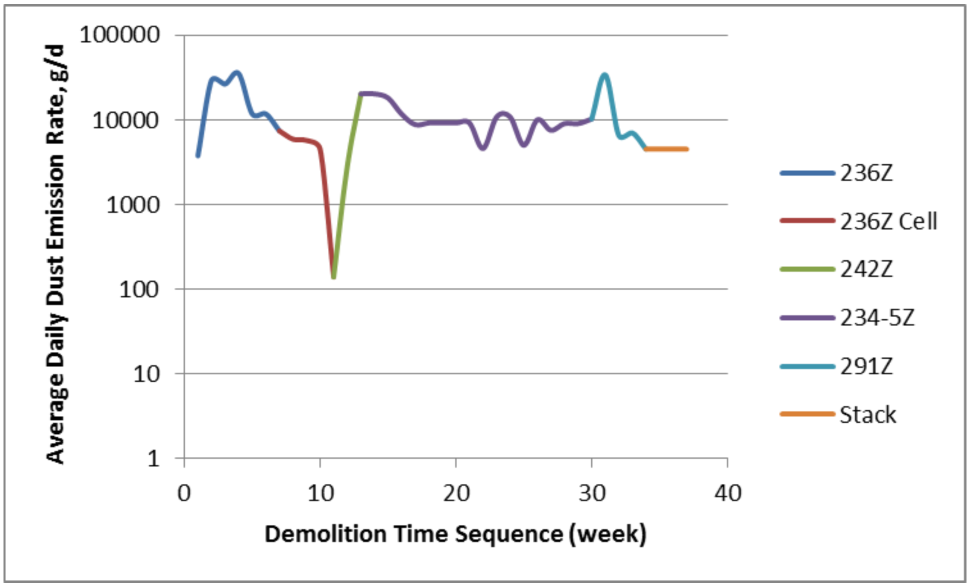

Figure 2.2. Weekly-averaged Dust Release Rate during Active Demolition and Load-out Activities

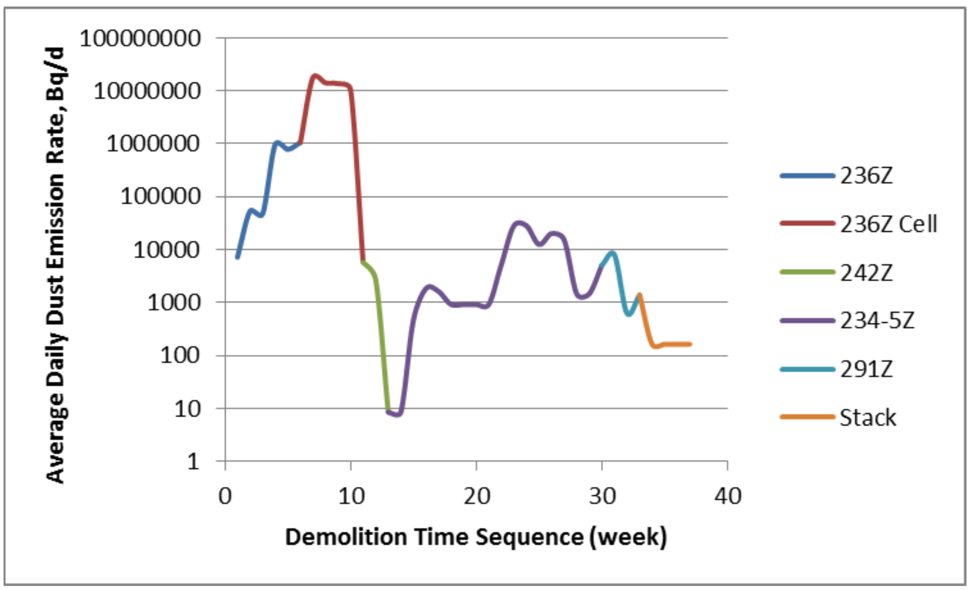

Figure 2.3. Weekly-averaged Radioactive Source Term During Active Demolition and Load-out Activities

2.6 Quality Control Procedures and Documentation

The quality control procedures for conducting these analyses are discussed in Appendix E. Source term and emission rate worksheets are documented in Appendix F. Appendix G documents the contents of selected AERMOD input and output files. These output files contain listings of both modeling inputs and results.

3.0 Predicted Impacts

The air concentration and surface deposition modeling efforts were conducted for demolition of all the PFP buildings as described in terms of the 17 demolition zones described in Section 2. The predicted potential impacts from demolition of all the PFP buildings are presented in Sections 3.1 and 3.2; impacts from the 291-Z-1 stack demolition are in Section 3.3. Component-based contributions to impacts are also presented for 1) the least contaminated structures and 2) the most contaminated structures.

The results presented in this section use a PFP facility area map shown in Figure 3.1 as a base map. The map includes the facility fence line (black) and the major roads (brown). The buildings and subsets of buildings being considered for demolition are shown as colored overlays. Structures shown in gray, some of which will be gone at the start of the PFP demolition activities, are not part of structures considered in this report. The structures marked in green(also marked as area 1) including 234-5Z (demolition zones 1 to 7), 242-Z (one demolition zone), and 291-Z (2 demolition zones) are the buildings in the PFP complex grouped as having lower overall contamination levels. The structures marked in orange(also marked as area 2) including 236-Z cell and associated structures (7 demolition zones) are the areas with higher levels of contamination. Also shown in Figure 3.1 is the PFP stack (marked in blue); the demolition of this structure is considered in Section 3.3.

The air exposure results presented below are the increments predicted to result from the demolition modeling – and as such do not contain a background component. The air monitoring stations in the immediate vicinity of the PFP complex will be only able to detect increments in air exposures from demolition if those increments are large enough to be distinguished from the local background. The background for this area is estimated to be on the order of 0.015 and 0.03 DAC-hours for 1-week and 2-week background exposures, respectively.[1]

The air dispersion modeling of the PFP building demolition addresses air concentration and surface deposition. Air concentration is characterized in terms of derived air concentration (DAC)-hour exposures summed over work-week time periods. Surface deposition is characterized in terms of cumulative deposition expressed in disintegrations per minute (dpm) per 100 cm^2 modeled over the elapsed time for the specific demolition activities under consideration.

[1] In an analysis of the routine air samplers (Napier et al. 2010), the mean of background air samples at the Hanford 200-West monitoring stations is shown to be about 1.2×10^{-15} μCi/ml of gross alpha-emitters. The DAC for the worst-case analysis of 236-Z is about 1.23×10^{-11} uCi/ml of alpha-emitters. Most of the background will be natural alpha-emitting radionuclides, primarily progeny of the uranium chain. If the background is assumed to have the same radionuclide spectrum as the contamination of the 236-Z building (which is conservative from a dosimetric sense), the background levels of air concentration are at about 0.0001 DAC; 1-week and 2-week background exposures are estimated to be about 0.015 and 0.03 DAC-hours, respectively.

Figure 3.1. PFP Structures Being Considered for Demolition

To evaluate the potential exposure levels from the planned demolition activity scenarios listed in Section 2 and detailed in appendices, the local patterns of air concentrations and surface deposition amounts were computed for each demolition-hour using annual cycles of 6 years of recent meteorological data (2004–2009). Activities are assumed to occur during about 8 hours each of a 10-hour day shift and 10-hour swing shift, with 4-day work weeks. Allowing for weekends and holidays, the start-to-finish demolition period for all the demolition activities is projected to be about 9 months.

The modeling of the potential impacts of this 9-month period of projected activities required characterization of the full sequence of day-to-day demolition activities. Two modeling approaches are used in AERMOD to analyze the potential air concentration and surface deposition:

1. Maximum-impact model runs were conducted for "worst case" demolition weeks (i.e., demolition sequences resulting in the greatest activity-based weekly emission rates) using the entire 6-year meteorological data period. The results of these runs provide a basis for climatologically defining the maximum impacts that could occur during any of the demolition activities, as expressed as the 95th percentile upper values.
2. Case-study model runs were conducted for the full projected sequence of releases. The results of these runs provide an indication of the order of magnitude of impacts that can be expected for sequences starting during different times of the year.

To maximize the number of time periods used in the climatological definition of peak exposure values, the air quality modeling of climatological peak exposures is conducted using 4-day instead of 7-day weeks. For air concentrations, each 4-day cumulative DAC exposure is the same that would be computed based on an expanded 7-day period (with no emissions on a 3-day weekend). For surface depositions, the modeling of each demolition activity is based on the number of demolition work-days rather than the elapsed time. Because the surface deposition results are based on cumulative deposition, the use of demolition work-days will provide predicted values for deposition computed over a shorter time period. The effect of using shorter times for computing peak surface depositions is considered conservative because they will tend to cover narrower ranges of ambient dispersion conditions. The demolition activities for all the PFP structures involve about 150 work-days. Of those efforts, a total of

39 work-days are projected for the 236-Z structures including the penthouse (24 days), and the cell demolition (15 days).

Maximum impact results for air concentration and soil deposition are presented separately for structures with the least contamination (234-5Z, 242-Z, and 291-Z demolition) and most contamination (236-Z cell and associated structures). These zones are shown above in Figure 3.1

3.1. Building Demolition – Air Concentrations

This section presents the air concentration modeling results for the demolition of the PFP buildings 234-5Z, 242-Z, 291-Z, and 236-Z. The results are presented as contour plots of 95th percentile air concentrations that represent the overall composite pattern of the "maximum" (expressed at the 95th percentile) weekly air concentrations at each receptor in the immediate area surrounding the demolition activity.

Maximum-impact modeling runs are used to define the "worst-case" (95th percentile – not exceeded more than 5% of the time) time-integrated air concentrations. The occurrence of the highest air concentrations will be associated with a coincidence of 1) demolition operations with the largest projected release rates and 2) the occurrence of the most limiting meteorological dispersion conditions. Although the operations for the PFP structures will extend over many months, the demolition of the more highly contaminated portions (i.e., areas that have the highest potential release rates) are projected to occur over a relatively short time period. To obtain the worst-case air concentrations, the maximum emission rates expected during planned work periods are modeled as potentially occurring anytime during the six-year (2004–2009) meteorological period.

Air concentrations are presented as contour plots of maximum values (expressed as total DAC-hours) resulting from weekly demolition activities. The highest, 4-day source term from the source term analysis discussed in Section 2.0 is used to define the worst-case emission rate in AERMOD. The resulting daily AERMOD concentrations outputs are post-processed to determine the 95th percentile 4-day air concentration at each PFP receptor location; the maximum air concentration contour plot presents the overall composite pattern of the maximum weekly air concentration at each receptor.

The air concentration contour plots represent the worst (at the 95th percentile) weekly exposure that could occur at a given location during demolition using a six-year period of historical (2004–2009) onsite meteorological data. The meteorological dataset is of sufficient duration that it is expected to include worst-case meteorological conditions that lead to bounding weekly air concentrations. Actual air concentrations that will occur during demolition will be defined by the ambient meteorological conditions that occur during the demolition process and are expected to be less than the predicted bounding values. Total weekly exposures are based on the total work-week exposures for all contiguous 4-day periods in the six years of meteorological observations.

3.1.1 Demolition of 234-5Z

This section presents the air concentration modeling results for the 234-5Z structures from demolition. These structures, which are labeled as demolition zones 1 through 7 in Figure 2.1, have less contamination than the 236-Z structure. As described in Section 3.1, the results are presented as contour plots of 95th percentile air concentration that represent the overall composite pattern of the maximum weekly air concentration at each receptor.

Figure 3.2 is the resulting contour plot of the maximum weekly air concentration (expressed as the 95th percentile of weekly total DAC-hours) for the 234-5Z PFP structures. Demolition zone 5 (the RMC Line - see Figure 2.1) results in the greatest weekly emission rate; all other demolition activities associated with zones 1 to 4 and zones 6 to 11 (see Figure 2.1) have lower weekly emission rates and therefore will have lower levels of predicted weekly peak exposures. No weekly fence line concentrations are predicted to exceed 0.1 DAC-hours.

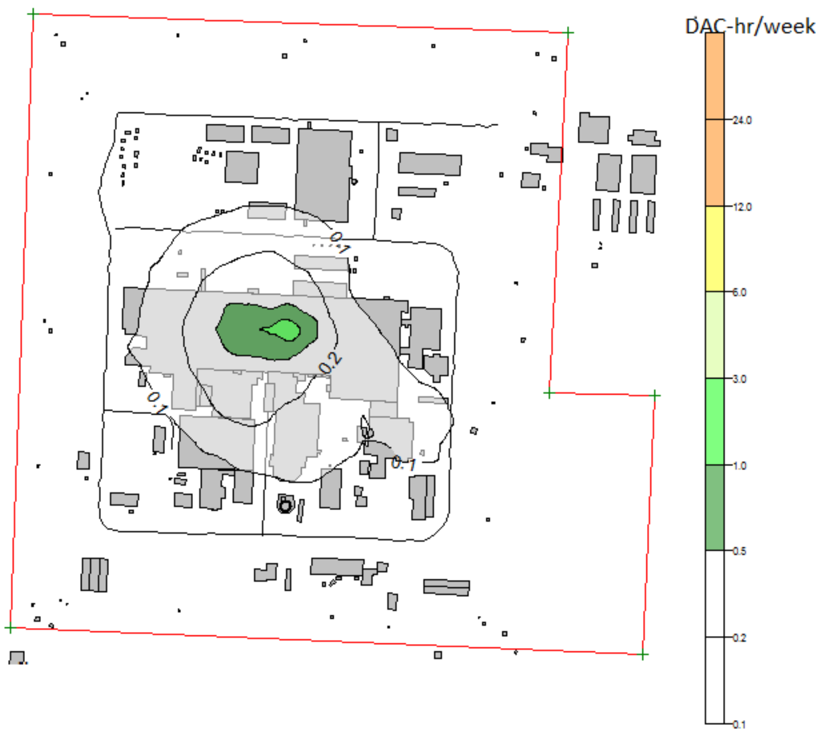

Figure 3.2. Predicted PFP Zone 5 Demolition Maximum Weekly Air Concentrations

3.1.2 Demolition of 242-Z

This section presents the air concentration modeling results for the 242-Z structure from demolition. This small structure has high residual concentrations of ^{241}Am. As described in Section 3.1, the results are presented as contour plots of 95th percentile air concentration that represent the overall composite pattern of the maximum weekly air concentration at each receptor.

Figure 3.3 is the resulting composite contour plot of the maximum weekly air concentration (expressed as the 95th percentile of weekly total DAC-hours) for the area surrounding the 242-Z PFP structure. This relatively small structure requires 2 working weeks to demolish. Demolition of the main operating room results in the greatest weekly emission rate; removal of the tanks and demolition of the tank room results in lower weekly emission rates and therefore will have lower levels of predicted weekly peak exposures.   No weekly fence line concentrations are predicted to exceed 0.1 DAC-hours.

Figure 3.3. Predicted 242-Z Demolition Maximum Weekly Air Concentrations

3.1.3 Demolition of 291-Z Building

This section presents the air concentration modeling results for the 242291-Z fan house structure from shear or mechanical hammer demolition. As described in Section 3.1, the results are presented as contour plots of 95th percentile air concentration that represent the overall composite pattern of the maximum weekly air concentration at each receptor.

Figure 3.4 is the resulting composite contour plot of the maximum weekly air concentration (expressed as the 95th percentile of weekly total DAC-hours) for the 291-Z PFP structure. This relatively small structure requires 3 working weeks to demolish. Demolition of the eastern roof results in the greatest weekly emission rate. No weekly fence line concentrations are predicted to exceed 0.1 DAC-hours.

Figure 3.4. Predicted 291-Z Demolition Maximum Weekly Air Concentrations

3.1.4 Demolition of 236-Z Cell and Associated Buildings

This section presents the air concentrations modeling results for the demolition of the 236-Z structure, which includes the cell and other associated buildings. The structure, which is denoted in orange in Figure 2.1, contains areas with the highest contamination levels in the PFP complex. Because the activity-weighted emissions from the 236-Z cell account for 98% of the projected emissions from all the 236-Z structures, the results presented in this section are associated with the demolition activities for the 236-Z cell.

Fifteen days of activities are projected in Section 2 for the demolition of the 236-Z cell. During those 4 work-weeks, the activity-weighted emissions from 236-Z account for more than 98% of the total emissions from all buildings. Also the highest weekly activity-based emission rate for all demolition for zones is only 0.5% of the average weekly rate for zone 12. Thus the levels of air exposures for demolition other buildings will be much less that those predicted for the 236-Z demolition four week period -- much lower air exposures will occur for the other 8 months of demolition activities.

The weekly emission rates for 236-Z vary with the portion of the structure being demolished. The first week that includes the dropping of the ceiling has the highest projected emission rate. The remaining weeks are projected to have emission rates that are only slightly less than the first week.

Three output products are provided for the 236-Z cell air exposure modeling: 1) maximum weekly air concentration contour plots for all (i.e., annual) dispersion conditions, 2) maximum weekly air concentration contour plots for monthly dispersion conditions, and 3) maximum weekly air concentration values at the facility fenceline.

3.1.4.1 Maximum Concentrations – All Dispersion Conditions

Six years (2004–2009) of onsite meteorological data were used to account for bounding, 95th percentile dispersion conditions leading to maximum predicted air exposure (expressed as weekly total DAC-hours) for the 236-Z cell; the resulting air concentration contour plot is presented in Figure 3.3. The results are based on the highest projected weekly emission rate during the 236-Z cell demolition, which is assumed to occur over any week within the six-year period. All other demolition activities associated with 236-Z cell and associated buildings demolition activities will have lower levels of weekly predicted peak exposures. No weekly fence line concentrations are predicted to exceed about 6 DAC-hours.

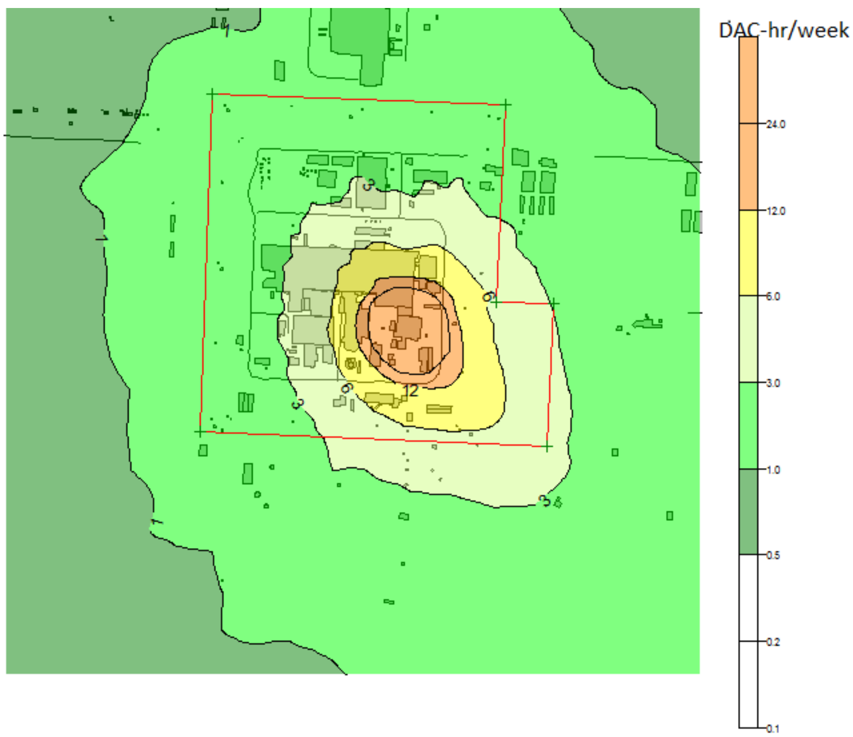

Figure 3.5. Predicted 236-Z Cell Demolition 95th Percentile Weekly Air Concentrations

3.1.4.2 Maximum Concentrations – Monthly Dispersion Conditions

Atmospheric conditions change with the seasons and the bounding values for the 95th percentile concentrations from a demolition activity can be expected to vary with the time of year. The seasonal implications for the 95th percentile concentrations are analyzed by computing monthly 95th Percentile concentrations from the 6- year (2004–2009) period in the same manner as described in Section 3.1.2.1.

Figures 3.4 to 3.15 are monthly 95th percentile air concentration contour plots for demolition of the 236-Z cell structures as described in Section 2. In all plots, the integration time is for one week. The 95th percentile one-week values for the given month from a 6-year (2004–2009) period are contoured in the plots.

Note that, because there are fewer days involved with each month as opposed to the entire 6-year period, the statistics are not quite as strong. As a result, the 95th percentile for some months is slightly higher than the 95th percentile for the entire period. This can be seen by comparing Figure 3.3 with Figure 3.4 or 3.15 (representing January and December, respectively), which show somewhat larger areas impacted by elevated concentrations of radionuclides in air. These months typically have many days with low wind speeds and “inversion-type” conditions with stagnant air and fog. The series of figures from 3.4 through 3.15 show that winter months have the highest potential for exceedance of Hanford Site administrative limits, while summer months have the lowest potential. To decrease the likelihood of exceeding 12 DAC-hours/week, demolition of 236-Z cell should be scheduled in a period of higher dispersion such as the period from about March through September.

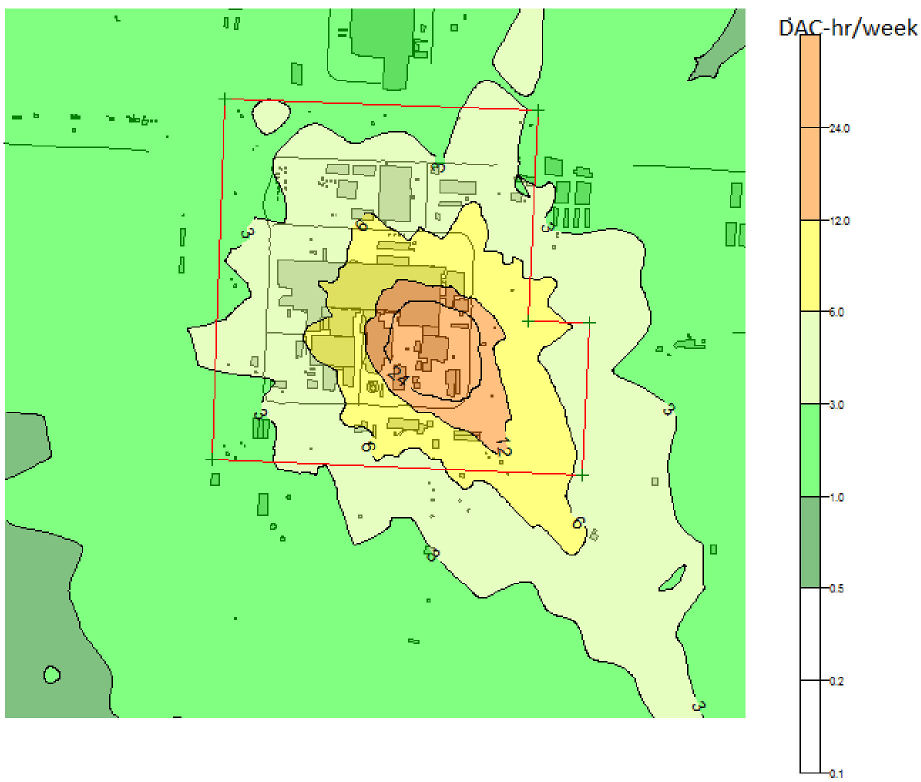

Figure 3.3. Predicted 236-Z Cell Demolition January 95th Percentile Air Concentrations

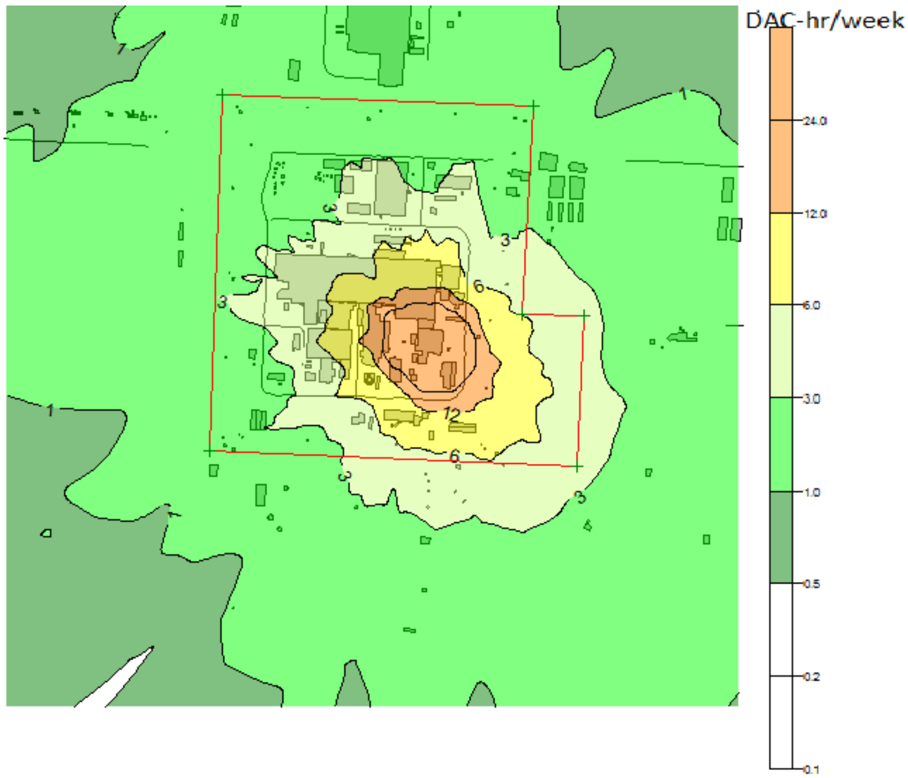

Figure 3.4. Predicted 236-Z Cell Demolition February 95th Percentile Air Concentrations

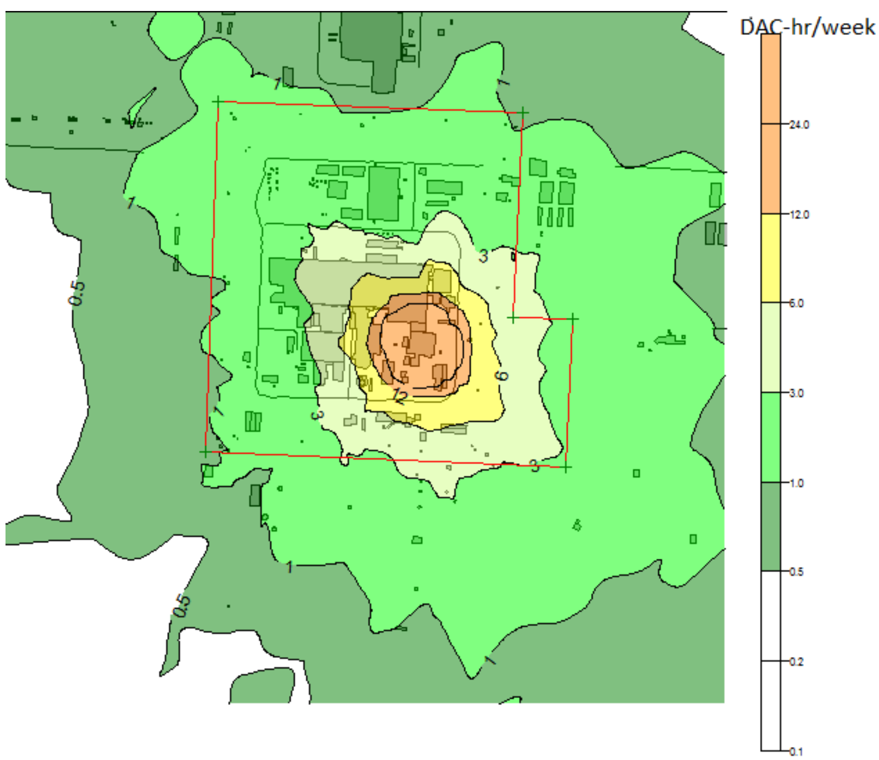

Figure 3.5. Predicted 236-Z Cell Demolition March 95th Percentile Air Concentrations

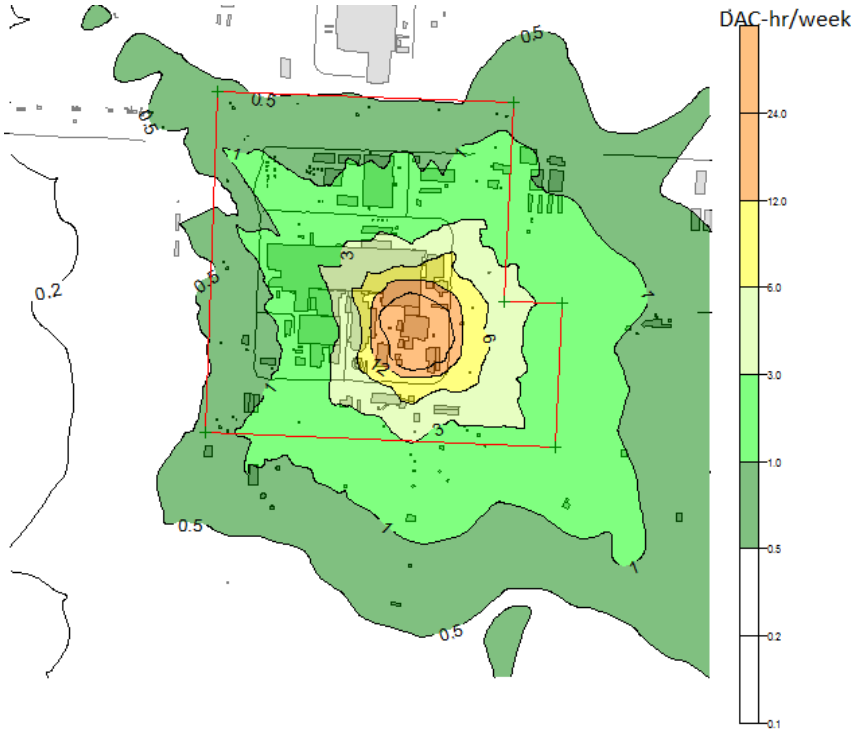

Figure 3.6. Predicted 236-Z Cell Demolition April 95th Percentile Air Concentrations

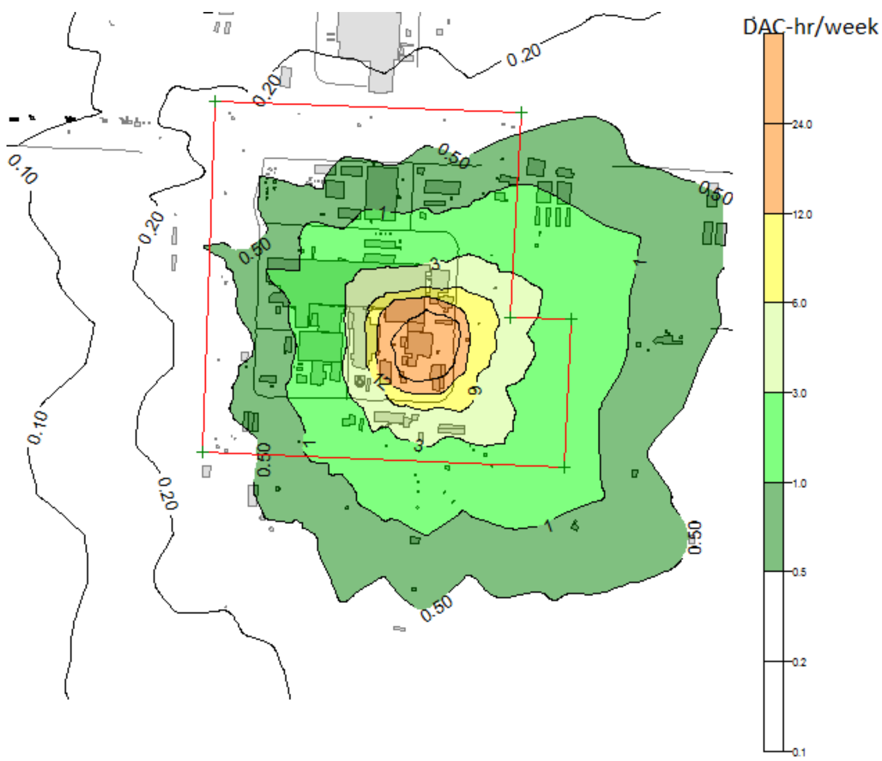

Figure 3.7. Predicted 236-Z Cell Demolition May 95th Percentile Air Concentrations

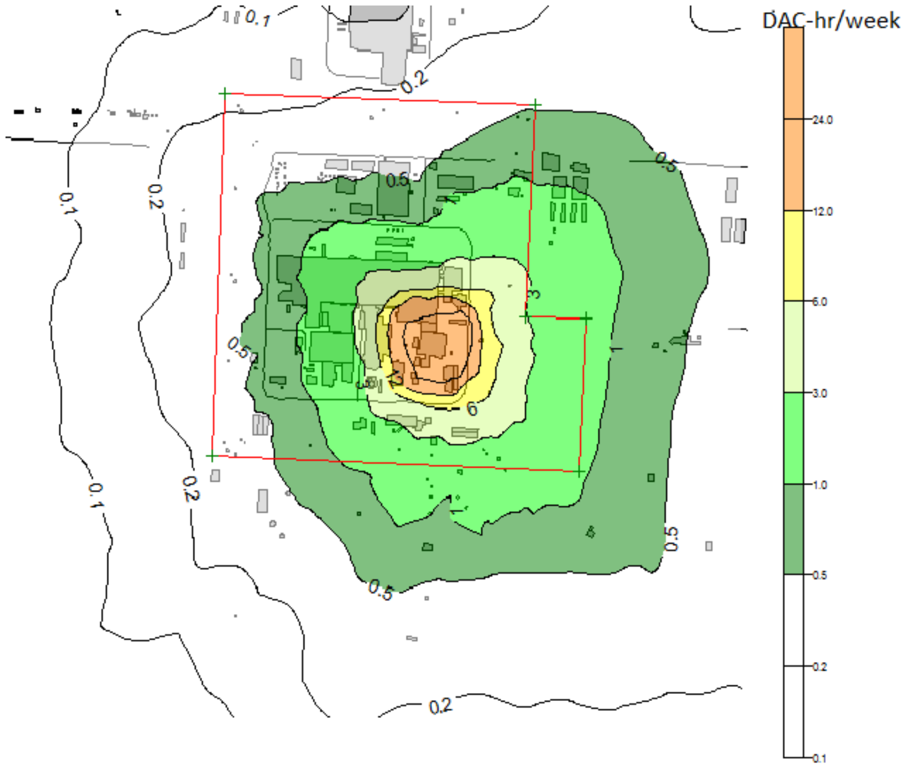

Figure 3.8. Predicted 236-Z Cell Demolition June 95th Percentile Air Concentrations

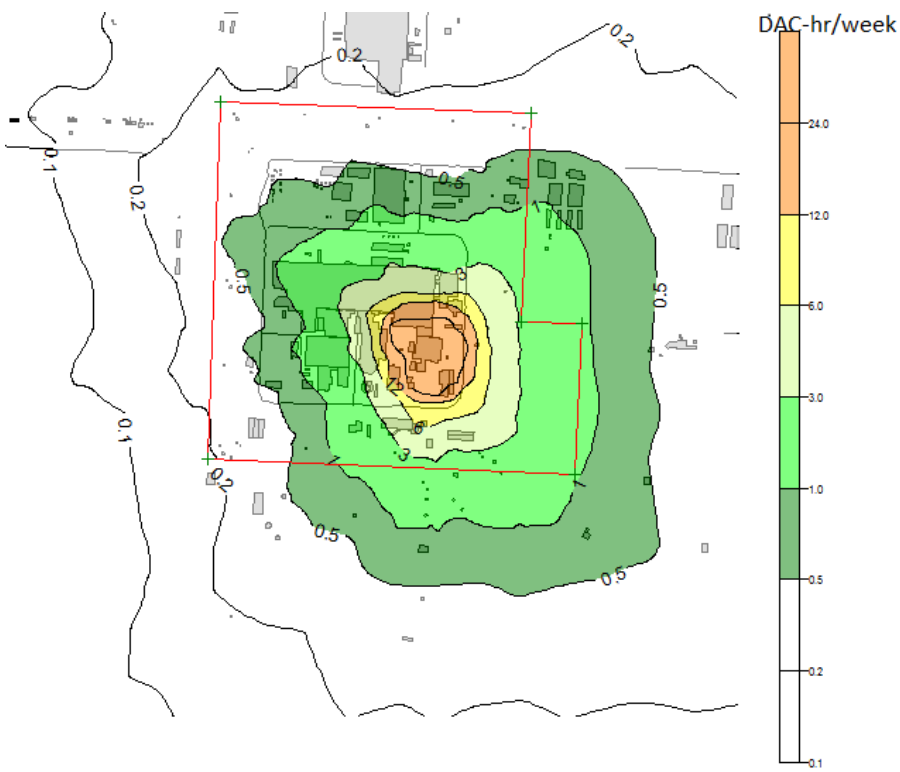

Figure 3.9. Predicted 236-Z Cell Demolition July 95th Percentile Air Concentrations

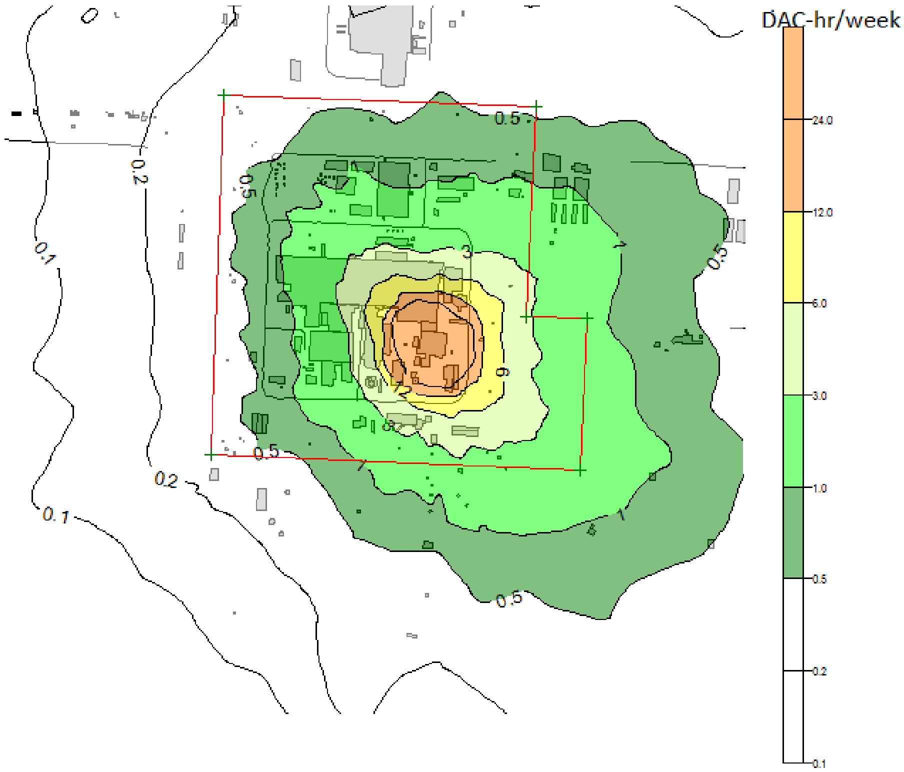

Figure 3.10. Predicted 236-Z Cell Demolition August 95th Percentile Air Concentrations

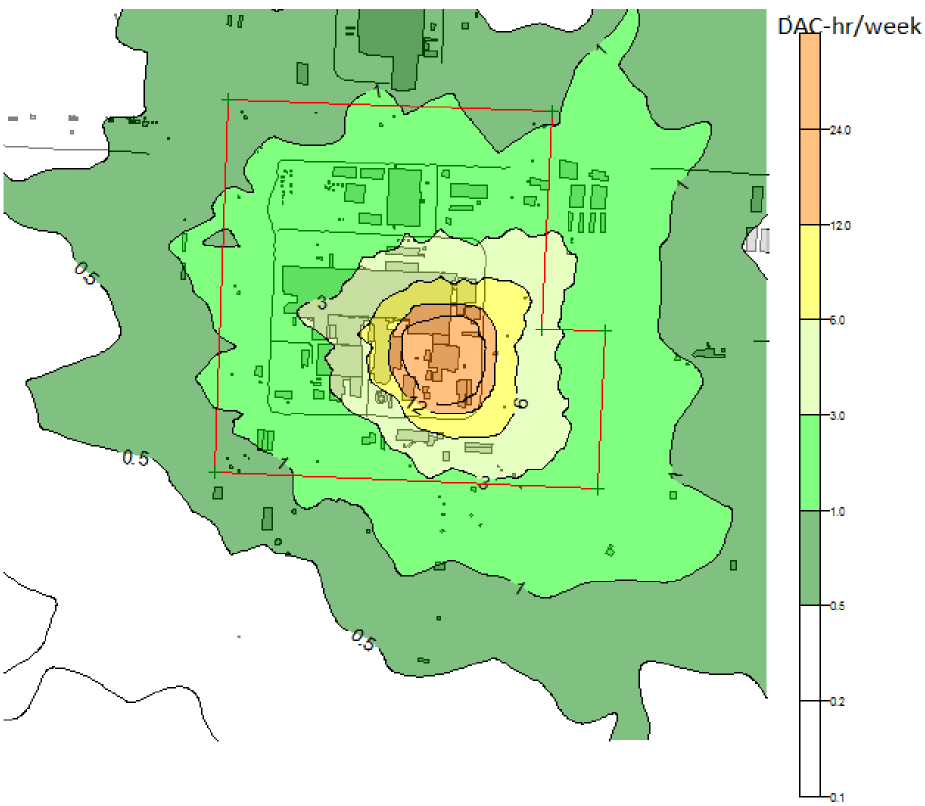

Figure 3.11. Predicted 236-Z Cell Demolition September 95th Percentile Air Concentrations

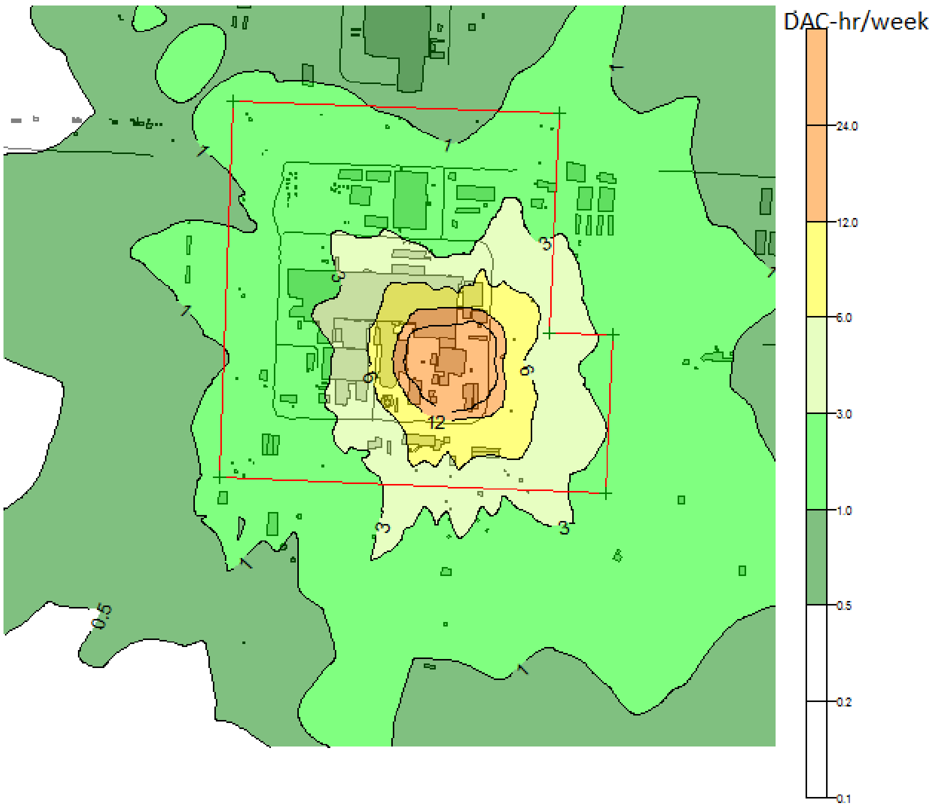

Figure 3.12. Predicted 236-Z Cell Demolition October 95th Percentile Air Concentrations

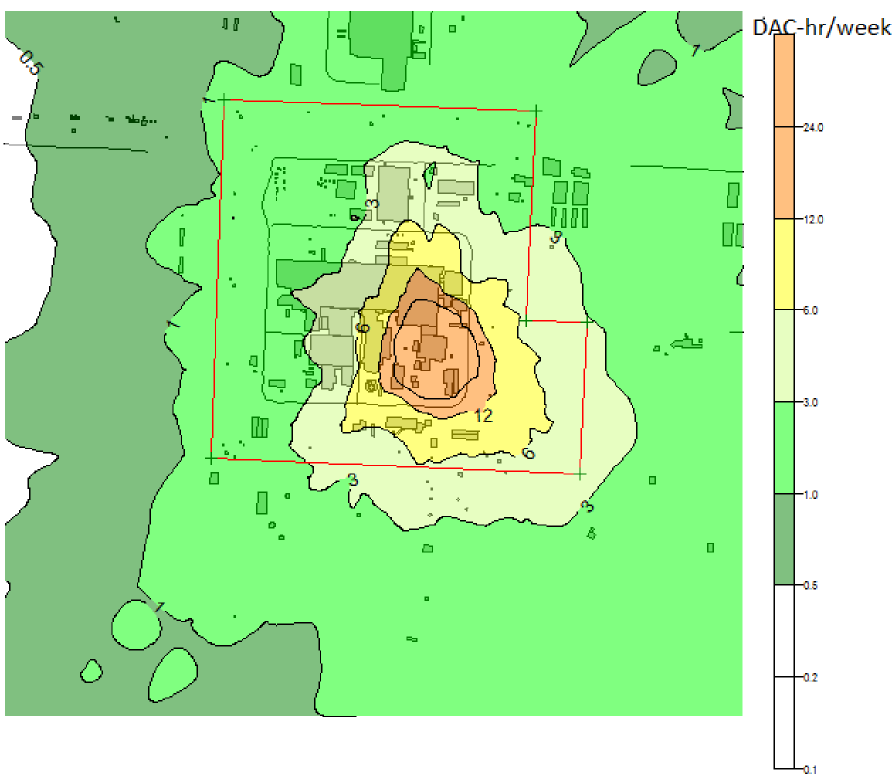

Figure 3.13. Predicted 236-Z Cell Demolition November 95th Percentile Air Concentrations

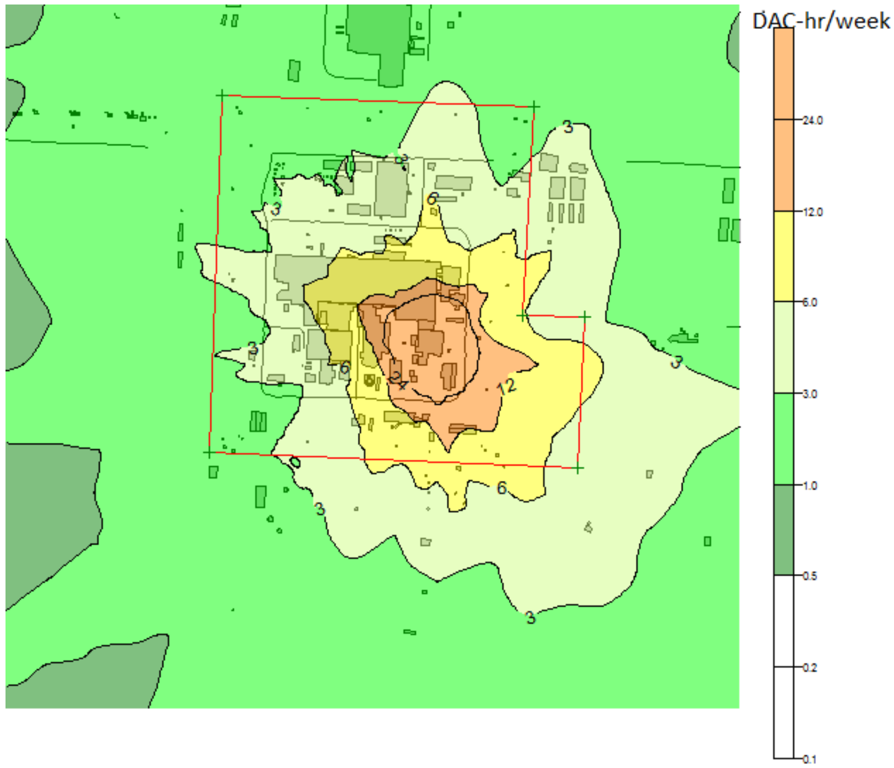

Figure 3.14. Predicted 236-Z Cell Demolition December 95th Percentile Air Concentrations

3.1.4.3 Maximum Concentrations at Facility Fenceline

The concentrations on the facility fenceline were modeled for a series of receptors located on that boundary. Figure 3.16 provides the resulting spatial distribution of the highest predicted 95th percentile weekly air concentrations (with units of weekly total DAC-hour) for each fenceline receptor for all of the PFP complex, excluding the 236-Z building demolition. Figure 3.17 provides the same information for only the 236-Z building demolition. It is apparent that open-air demolition of the 236-Z building results in the largest contribution to airborne concentrations of radioactive materials.

The results in Figures 3.16 and 3.17 represent the highest estimated emission rates occurring under the most restrictive dispersion conditions. The actual exposures during demolition activities will be a function of combinations of emission rates and ambient atmospheric conditions that occur during those activities.

In these figures, the absolute highest concentration estimated exceeds the 95th percentile by a factor of 3 or less. Thus, these figures indicate that there is a high likelihood that the Hanford Site administrative limit of 12 DAC-hours/week will not be exceeded beyond the current PFP fenceline.

Figure 3.15. Predicted 95th Percentile Weekly Air Concentrations at the PFP Site Fenceline for Demolition Excluding the 236-Z Plutonium Reclamation Facility (DAC-hours). Location with value noted in red (0.04 DAC-hours) is largest 95th percentile.

Figure 3.16. Predicted 95th Percentile Weekly Air Concentrations at the PFP Site Fenceline for the 236-Z Plutonium Reclamation Facility Cell Demolition (DAC-hours). Location with value noted in red (5.3 DAC-hours) is largest 95th percentile.

3.2 Building Demolition – Surface Deposition

Surface deposition is analyzed through 95th percentile impact modeling runs. The 95th percentile surface deposition is determined by modeling the average emission rate for a given demolition activity over the entire 6-year (2004–2009) meteorological period. The resulting model-calculated daily surface deposition values are then summed over the actual number of days the activity is expected to be performed and the total deposition value at each receptor location is retained and sorted. These 95th percentile contour plots are presented in this section for a variety of demolition activities; contours are expressed in units of alpha disintegrations per minute (dpm) per 100 cm^2.

Actual surface deposition that will occur during demolition will be defined by the ambient meteorological conditions that occur during the demolition activities.

3.2.1 234-5 Z, 242-Z, and 291-Z Demolition

This section presents the predicted 95th percentile surface deposition modeling results for the 234-5Z, 242-Z, and 291-Z structures from demolition. These structures, which are shown in Figure 2.1, have less contamination than the 236-Z structure. Of the buildings, 234-5Z has the largest total activity-based emissions and will therefore dominate the surface deposition pattern. The 234-5Z, 242-Z, and 291-Z activities leading to surface deposition from demolition were projected to occur for a total of 70 days, 7 days, and 18 days, respectively.

Figure 3.18 is the resulting contour plot of the 95th percentile surface deposition (expressed as alpha dpm per 100 cm^2) for the entire 234-5Z demolition. The 95th percentile deposition is determined by modeling the average emission rate for a given demolition activity over the entire 6-year (2004–2009) meteorological period. The resulting model-calculated daily surface deposition values are then summed over the actual number of days the activity is expected to be performed and the total deposition value at each receptor location is retained, sorted, and output for contour plotting.

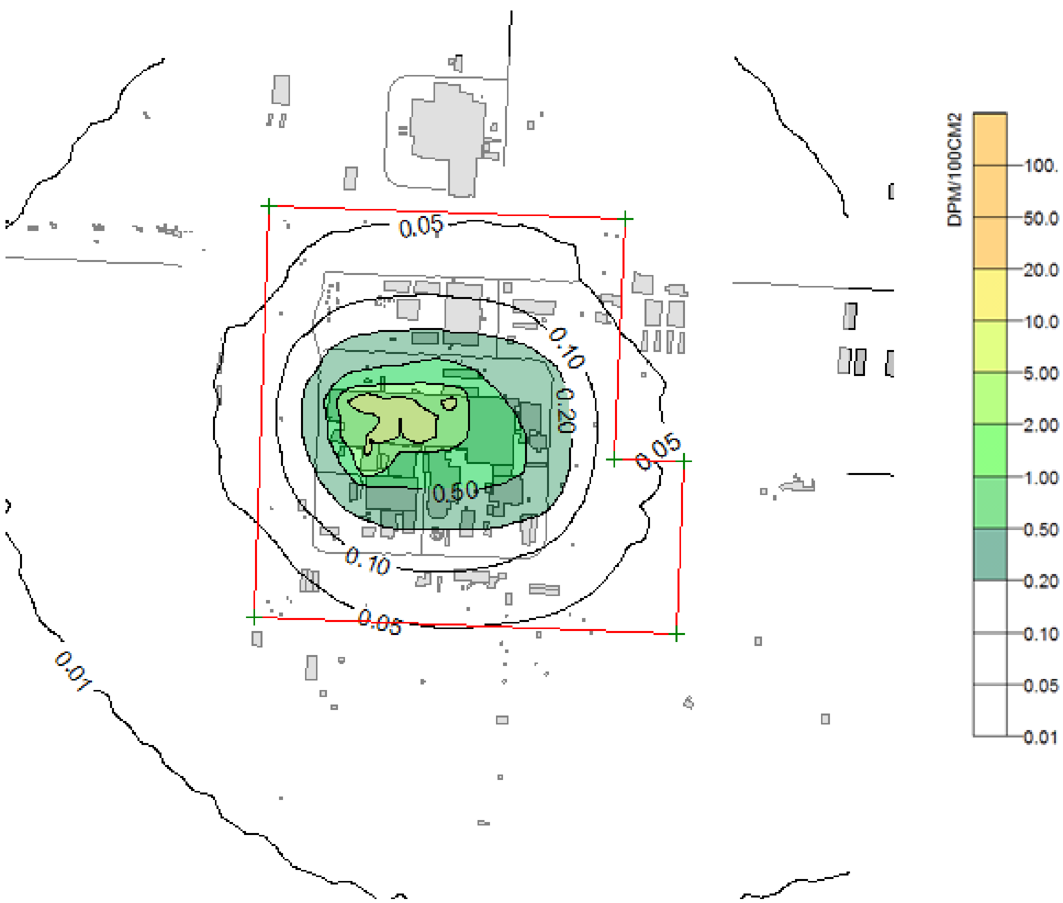

Figure 3.17. 234-5Z Demolition 95th Percentile Surface Deposition

3.2.2 236-Z Demolition

This section presents the surface deposition modeling results for the 236-Z cell and associated buildings; these structures are identified in orange in Figure 2.1. The 236-Z structures have the highest contamination levels in the PFP complex. Because the activity-weighted emissions from the 236-Z cell account for about 98% of the projected emissions from demolition of all the 236-Z structures, the results presented in this section are associated with the demolition activities for the 236-Z cell. The 236-Z structure demolition activities leading to surface deposition were projected to occur for a total of 39 working days of which 15 days are related to the 236-Z cell.

Figure 3.19 is the resulting composite contour plot of the 95th percentile surface deposition (expressed as alpha dpm per 100 cm^2) for demolition of the 236-Z cell. As noted in Section 3.2, the 95th percentile deposition is determined by modeling the average emission rate for a given demolition activity over the entire 6-year (2004–2009) meteorological period. The resulting model-calculated daily surface deposition values are then summed over the actual number of days the activity is expected to be performed and the total deposition value at each receptor location is retained, sorted, and output for contour plotting. For the 236-Z cell, activities leading to surface deposition from demolition were projected to occur for a total of 15 days.

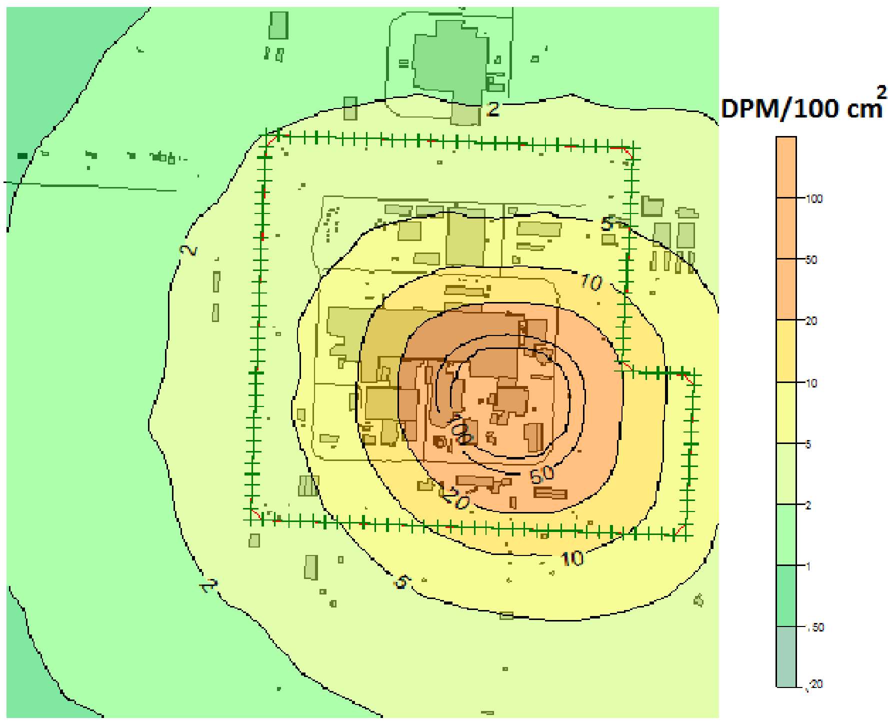

Figure 3.19. Predicted 95th Percentile Surface Deposition for 236-Z Cell from Demolition

3.2.3 Total Deposition from All PFP Buildings

The climatologically-based pattern of predicted 95th percentile soil exposures (expressed as DPM per 100 cm^2) from demolition of all PFP buildings is shown in Figure 3.20. The plot for all buildings is essentially identical to the plot for 236-Z that represented more than 98% of the total projected emissions from demolition of all the PFP buildings. The activities leading to surface deposition from demolition of all the PFP buildings were projected to occur for a total of about 150 days.

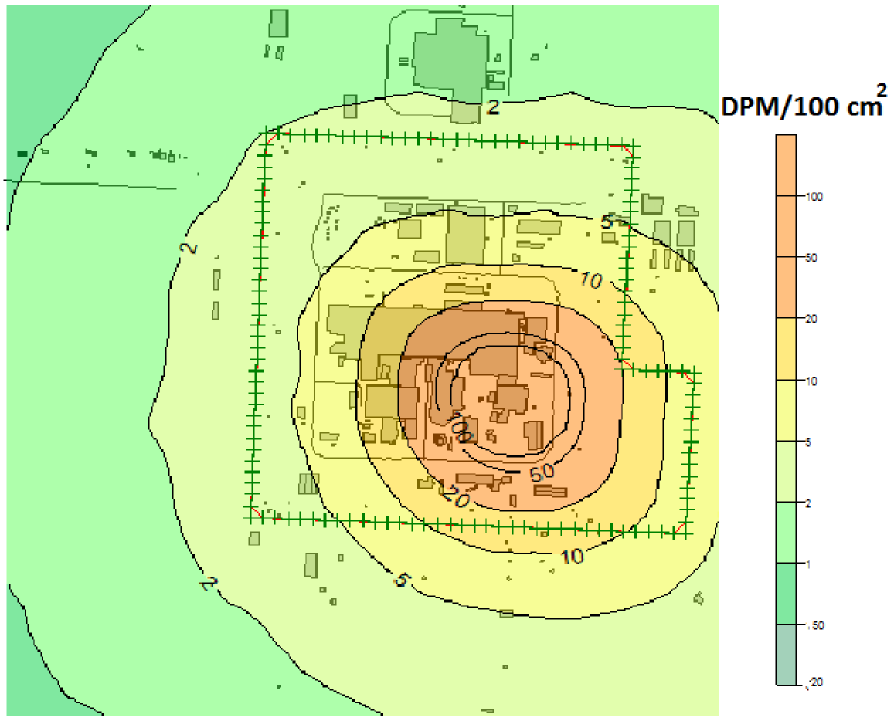

Figure 3.180. Predicted 95th Percentile Surface Deposition for Demolition of all PFP Buildings

3.3 Stack Demolition - Air Concentration and Surface Deposition

The 291-Z-1 demolition scenario is detailed in Section 2. The 95th Percentile air concentration and surface deposition values were modeling in the same manner as described in Sections 3.1 and 3.2. The computations are based a 6-year (2004–2009) period of local meteorological data.

Figure 3.21 presents a composite contour plot of the resulting maximum weekly (95th percentile) air concentration for demolition of the 291-Z-1 stack structure. The results are based the a composite of the maximum weekly values from the receptor locations in the area surrounding the demolition activities.

Figure 3.22 presents the resulting maximum (95th percentile) surface deposition during the demolition of the 291-Z-1 stack structure. The results are based on modeling the potential values of cumulative surface deposition occurring during the demolition. The contour plot is based on a composite of the maximum (95th percentile) cumulative surface deposition computed at an array of receptor locations covering the area surrounding the demolition.

The predicted 95th percentile air concentration and maximum cumulative deposition values occur in the immediate vicinity of the demolition activity – and have very low values; no additional analyses of the potential air exposures were conducted. The modeling indicates that the worst-case concentration increments from the stack demolition will be too small to be detectable.

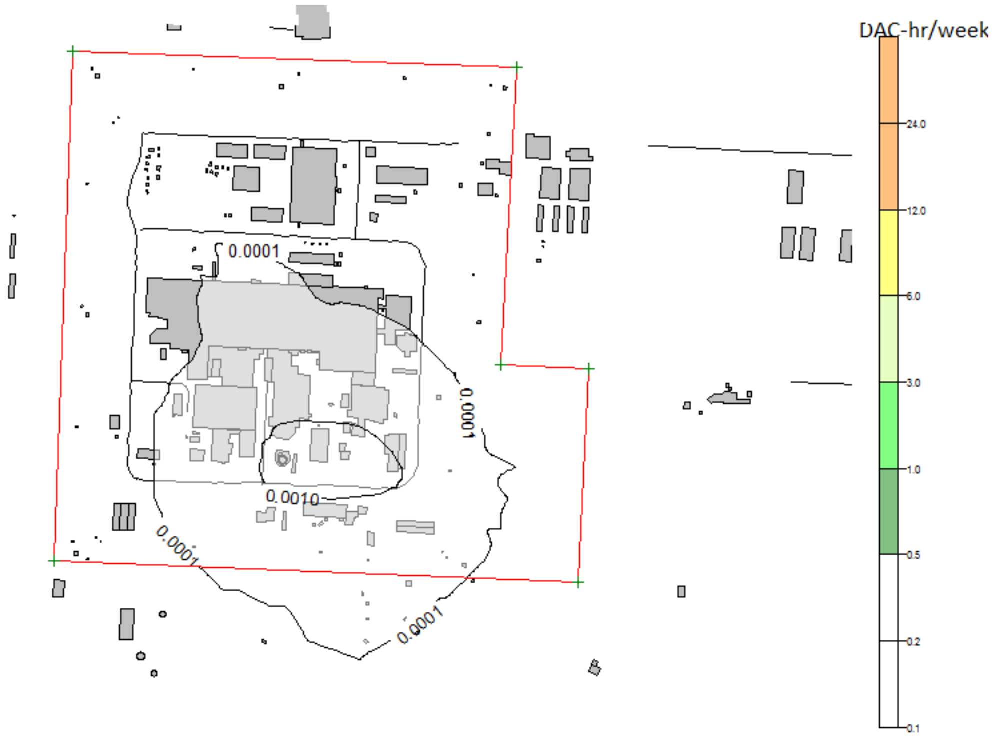

Figure 3.19. Predicted Weekly Air Exposure 95th Percentile Values for 291-Z-1 Stack Demolition

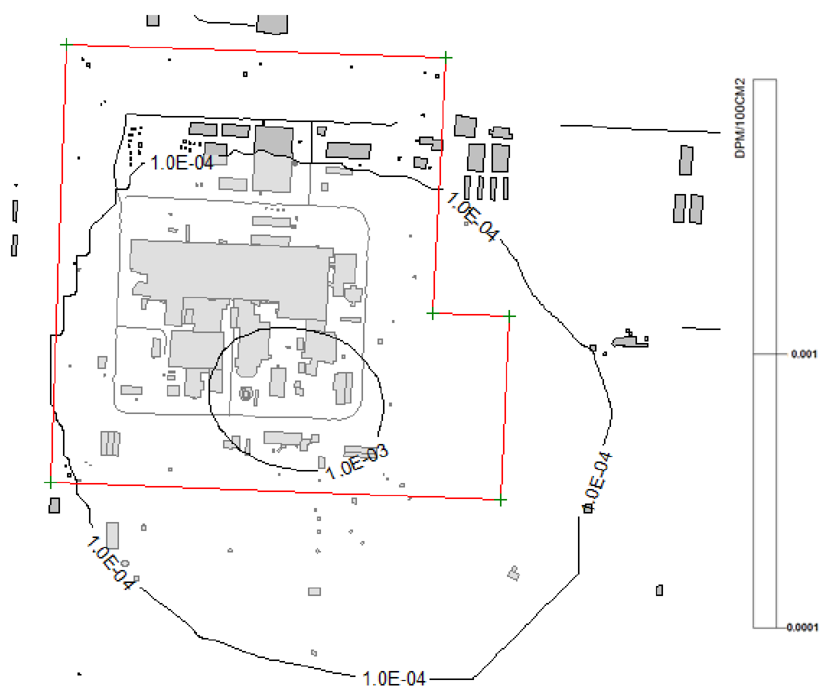

Figure 3.202. 95th Percentile Surface Deposition for the 291-Z-1 Stack Demolition

4.0 Discussion of Results

The source-term analysis projected the levels of releases of radioactive material that is to be anticipated during the demolition of the Plutonium Finishing Plant (PFP) facilities. The modeling results presented here are closely tied to the details of how the demolition is to be conducted. The shearing or mechanical hammering option using emission mitigation methods was considered for all the proposed demolition activities. This option represents a standard demolition approach that has been used in several past demolition efforts at Hanford. These modeling results indicate that the radiological exposures from the planned demolition efforts will be below the designated limits for air and soil exposures for the bulk of the PFP facilities, including the PFP stack.

The releases from 236-Z (and in particular the 236-Z cell) produce predicted air concentration increments that are of concern in terms of the projected worst-case 95th percentile levels of air exposures. The assumed shearing or mechanical hammering demolition option that includes extensive pre-demolition structure decontamination and preparation is widely used for demolition of structures with hazardous contamination. However, for demolition of this portion of the facility using this demolition option, the modeling results indicate a potential to spread contamination in excess of Hanford administrative limits beyond the edges of the current buildings but not beyond the current fenceline of the PFP area. It needs to be noted that the analysis assumed remaining contamination levels in the 236-Z cell are at an average of 25 nCi/gram. It is possible that different methods and/or extensive decontamination could reduce the contamination levels, and thus reduce the levels of potential exposures.

In summary, this report documents anticipated releases and environmental contamination that could be expected for open-air demolition of the PFP facilities for a basic scenario using typical demolition techniques. These results are provided for planning purposes. This report does not document any decisions about the decommissioning approaches.

5.0 References

40 CFR Part 51. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 51, "Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule."

AlphaTRAC. 2003a. *Demolition Scenarios and Source Terms for Atmospheric Modeling.* AlphaTRAC, Inc., 8670 Wolff Court, Suite 120, Westminster, Colorado 80031.

AlphaTRAC. 2003b. *Technical Review of Atmospheric Modeling for the 233-S Demolition Project at the Hanford Site.* AlphaTRAC, Inc., 8670 Wolff Court, Suite 120, Westminster, Colorado 80031.

DOE – U.S. Department of Energy. 1994. DOE Handbook, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Volume 1 - Analysis of Experimental Data. DOE-HDBK-3010-94, Washington, D.C.

DOE – U.S. Department of Energy. 1998. Title 10, U.S. Code of Federal Regulations, Part 835. Occupational Radiation Protection. FR 63:213, pp. 59662-59689, Washington, D.C

Droppo JG, Napier BA. 2006. *Analysis of Radioactive Releases During Proposed Demolition Activities for the 232-Z Building*, PNNL-15851, Pacific Northwest National Laboratory, Richland, Washington.

Droppo, JG, Jr, Napier BA. 2011."Use of Source Term and Air Dispersion Modeling in Planning Demolition of Highly Alpha-Contaminated Buildings." *Proceedings of the 14th International Conference on Environmental Remediation and Radioactive Waste Management (ICEM 2011)* , September 25 – 29, Reims, France.

EPA – U.S. Environmental Protection Agency. 1995. Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume 1: Stationary Point and Area Sources. Research Triangle Park, North Carolina.

EPA – U.S. Environmental Protection Agency. 2008. Technology Transfer Network Support Center for Regulatory Air Models, http://www.epa.gov/scram001/(Access last checked 6/5/2008).

Napier BA, Droppo JG, Rishel JP. 2008. *Analysis of Radioactive Releases During Proposed Demolition Activities for the 105-KE Basin*, PNNL-17631, Pacific Northwest National Laboratory, Richland, Washington.

Napier BA, JP Rishel, JG Droppo. 2009. *Analysis of Radioactive Releases during Proposed Demolition Activities for the 224-U and 224-UA Buildings*. PNNL-18332, Pacific Northwest National Laboratory, Richland, Washington.

Napier BA, Rishel JP, Droppo JG., Strom DJ, Joyce KE. 2010. *Analysis of Radioactive Releases during Proposed Demolition Activities for the 224-U and 224-UA Buildings*. PNNL-18332 Addendum , Pacific Northwest National Laboratory, Richland, Washington.

Appendix A

Facility-Specific Source Term Analyses

Appendix A – Facility-Specific Source Term Analyses

A.1 236-Z (Plutonium Reclamation Facility)

The 236-Z building (also known as the Plutonium Reclamation Facility – PRF) is located south of the southeastern corner of the 234-5Z building and is connected to it by the 242-Z building. The building is a four-story structure 24 m (79 ft) by 21.6 m (71 ft) by about 14.5 m (47.5 ft) high, surmounted at the southwest corner by a two-story penthouse 6.9 m (22.5 ft) high. With the exception of the roof, the south end of the process cell, and the fourth-floor ceiling, the building is constructed of reinforced concrete. The roof is constructed of an open-web steel joist frame, a steel deck with rigid insulation of lightweight concrete fill, and gravel-covered built-up roofing. A portion of the south wall is also the 1-ft-thick wall of the process cell. An equipment transfer facility is located against the large south door. The tanks and columns used in the solvent extraction process were located in the process cell—a large three-story room in the center of the 236-Z building. Most of the residual contamination is expected to be in the process cell and on the outer walls of the process cell.

Amounts, locations, and isotopic mixtures of residual contamination in PFP complex buildings including 236-Z were provided by a CHPRC team (Brian Oldfield and Peter Sauer). These were provided as a series of spreadsheets. These source terms were modified and simplified through discussions with CHPRC staff. It was assumed that all the plutonium is in an oxide form, and assumed to be in small, dispersed particles (see HNF-SD-PRP-HA-002, Rev.5, Section 4.2.1.4); the nature of the activities in the 236-Z building – and the residual liquid stains on the walls – tend to the idea that the material in this building is largely in the chemical form of soluble nitrates.

The assumed conditions of 236-Z prior to demolition include:

- The canyon floor is cleaned and covered with a layer of clean grout (or equivalent) for the duration of the demolition
- all above-grade plutonium nitrate transfer lines and encasements removed
- all liquid waste lines that depart the building will be isolated and capped at sufficient distance from the building as to no longer be involved in the air modeling equations
- The following pieces of equipment are assumed to remain in the building for surgical removal during the demolition process:

Location	Item	QTY	Unit	Pu (g)
6th Floor	6th Floor Column	1	Gloveboxes	170
5th Floor	Filter Box 50	1	Filter Boxes	3
5th Floor	5th Floor Column	1	Gloveboxes	134
4th Floor	MT-1	1	Gloveboxes	133
4th Floor	MT Conveyor	1	Gloveboxes	86
4th Floor	MT-3	1	Gloveboxes	118
4th Floor	MT-4	1	Gloveboxes	129
4th Floor	MT-5	1	Gloveboxes	194
4th Floor	MT-6	1	Gloveboxes	172

4th Floor	4th Floor Column	1	Gloveboxes	112
4th Floor	4th Floor Column Crit	1	Gloveboxes	29
3rd Floor	Filter Box 36	1	Filter Boxes	3
2nd Floor	Filter Box 20E	1	Filter Boxes	3
2nd Floor	Filter Box 20W	1	Filter Boxes	15
2nd Floor	2nd East Gallery	3	Gloveboxes	294
2nd Floor	2nd West Gallery	3	Gloveboxes	272
2nd Floor	A/B/C/D Exhaust Filters	48	Filter Boxes	4
1st Floor	Filter Box 10E	1	Filter Boxes	23
1st Floor	Filter Box 10W	1	Filter Boxes	1
1st Floor	1st East Gallery	3	Gloveboxes	368
1st Floor	1st West Gallery	3	Gloveboxes	400
Canyon	Strongbacks	41	Strongbacks	185

- The various equipment items are assumed to be prepared with fixatives such as "FireDam-200" (described at http://multimedia.3m.com/mws/media/373702O/3mtm-firedamtm-spray-200-brochure.pdf and viewable on YouTube). The removal process involves preparation and armoring of the various pieces of equipment. As access is provided by demolition of nearby walls or ceilings, the equipment is then lifted from within the building and placed in a nearby disposal container.

Contamination is on surfaces, under floor tile, under paint, etc. The anticipated contamination levels within the building were provided by the CHPRC analysts (workbook dated 3 November 2015 by Peter Sauer). The overall contamination levels, excluding the process cell, are as follows:

Zone	Description	Debris Wt (lb)	Area (SF)	Alpha (dpm/100cm2)	Alpha (uCi)
SZ-1	236-Z 6th Floor	193228	1216	2,000	10.2
SZ-2	236-Z 5th Floor	165469	1074	2,000	9.0
SZ-3	236-Z 4th Floor	1158363	7081	2,000	59.3
SZ-4	236-Z 3rd Floor	1051893	2629	2,000	22.0
SZ-5	236-Z 2nd Floor	1102836	6640	2,000	33.0
		19750	4700	1,700,000	33,436.7
SZ-6	236-Z 1st Floor	1122587	6613	2,000	55.3
	Totals	4794376	25252		33,625.5

The main process cell has significant amounts of radioactive contamination; most is fixed within the concrete walls of the facility. The floor of the cell will be covered with a layer of cementitious grout prior to demolition; the inventory of the floor is omitted from this analysis. For simplicity, it is assumed that the materials of the walls and ceiling of the cell are all uniformly contaminated to a level of 25 nCi/gram. Given the mass of the structure, this is an estimated 23.4 alpha curies (a total contamination of 60 curies alpha, beta, and gamma) – over 98% of the total residual contamination in the building and remaining equipment.

The demolition schedule assumes that the overall demolition would require about 39 working days (about 10 weeks elapsed time). It is assumed that the 236-Z building is the first to be demolished - this schedule essentially works from one end of the complex to the other.

A.1.1 Initial Building Demolition

Demolition will begin on the upper levels of the building. One day is allocated for removal of the top story of the 236-Z penthouse structure (because of the height and the necessity to lower debris to ground level). A second day is allocated for removal of the 6^{th} story column hood. Similarly, the 5^{th} story portion of the penthouse requires one day; the portion of the column hood on the 5^{th} story and Filterbox 50 are removed on the 4^{th} day.

Major demolition begins with removal of the main building roof and walls of the 4^{th} story. Three working days are allocated for this demolition. Two more days are allocated for removal of the 4^{th} story gloveboxes and column hood.

A similar 3-day period is allocated for removal of the 4^{th} story floor/3^{rd} story ceiling and walls – with the exception of the ceiling of the main cell, which constitutes part of the 4^{th} story floor. Filterbox 36 is removed during swing shift of the 13^{th} day.

The second story holds a bank of air filters. It is assumed that most ducting is removed prior to major demolition but that the filter banks remain. It is assumed that an opening is made and the filters are removed essentially intact. This is assumed to take 1 working days. Then the remainder of the 2^{nd} story ceiling/3^{rd} story floor is removed along with walls over three working days. Two days are allocated for careful removal of the galleries located on the second story.

The 19^{th} day is allocated for removal of the bank of filters on the 1^{st} floor. The remainder of the outer portions of the 1^{st} story are removed over a three day period. Finally, two days are allocated to carefully remove the galleries located on the first floor. This work results in the exposure of the tops of tunnels under the 1^{st} floor; one day is allocated to carefully remove piping from these tunnels.

As a result of this work, only the 2-foot-thick walls and ceiling of the main cell remain. All work on these sections of the building is assumed to be performed with hydraulic concrete shears or mechanical hammer mounted on a long boom on a track-mounted vehicle from ground level.

The bulk of the contamination within the 236-Z building is associated with the inner and outer walls of the main cell. Leaks and spills of plutonium solutions have contaminated the insides of the cell and also the back walls of the gloveboxes on both sides on the first and second stories. The high contamination levels may require precision demolition techniques

As noted above, there is a large number of penetrations through the cell walls on the first and second stories, originally within the galleries on the west and east side walls. These penetrations contained the piping and connectors for the jumpers to the pencil tanks. It is assumed that significant contamination remains within the piping and components of these jumper receptacles, and that each will need to be removed and treated as transuranic (TRU) waste separately from the general rubble of the cell walls. This adds to the complexity of the cell wall demolition; each of the several-dozen jumper receptacles will need to be individually removed and packaged – which will require slow demolition with time and effort to recover these pieces. These pieces must be individually cut out of the wall (or the wall carefully removed from around them).

A.1.2 Demolition of Cell with Shears or Mechanical Hammer

The cell ceiling and walls will be removed with the multiprocessor hydraulic shears or mechanical hammer. The walls are to be demolished from the top down, using a large excavator to manipulate the multiprocessor. This device will crush the concrete into roughly 1-foot pieces. (The ERDF acceptance criteria include requirements that the pieces be sized into less than one-foot cubes.) A hypothetical schedule is described, upon which is based the emissions estimates. Misting, water, and fixatives will be used throughout the demolition process and load-out to minimize spread of airborne contamination. Demolition will only occur when sustained wind speeds are less than 20 miles per hour.

In order to make access easier, the south wall is then removed. This wall is thinner (1 foot) and contains a 12-foot wide door extending into the second story. The door is topped with a concrete beam; above that construction is of cinder block. Demolition of this wall takes one day.

For structural reasons, it is assumed that the southern half of the ceiling/roof of the cell is removed in one day. The floor of the cell is assumed to be covered with grout (or a similar substance) to absorb the impact of falling debris and to minimize suspension of floor contamination. This action opens the main cell to the atmosphere for the remainder of the demolition. At this point, the pre-packaged strongbacks are removed through the southern opening.

The ceiling and structural materials high in the cell are assumed to be removed the fourth day. The crane maintenance platform at the north end of the cell, and the crane itself, are removed. The Maintenance Station in the northeast corner of the cell is removed, including the small shield wall.

Demolition of the east and west side walls is complicated by the inclusion of numerous jumper receptacles, which are assumed to require handling as TRU waste. The upper portion of the wall above the top line of jumper receptacles is crushed and dropped to ground level. The areas between the jumper receptacles are then crushed and the receptacles themselves knocked out one at a time for recovery and packaging. One day is allocated for demolition of the upper portion of the wall (the third story and top few feet of the second story), and 1 day for the receptacles on the 2^{nd} story. The next portion of wall is removed (1 day) and then the next line of 1^{st} floor receptacles (1 day). A final day is allocated for removal of the lowest portion of the wall below the lowest line of penetrations. The entire process is then duplicated for the opposite wall (5 more days).

Finally, the north wall is removed. One day is allocated for this activity, including any final cleanup of the area.

Falling rubble is generally directed into the cell, rather than out into the surrounding area. Pick-up of rubble is done with a front loader and thumb-and-bucket on the excavator. The rubble will be picked up and placed into transfer boxes just outside the location of the door in the south wall, in the general area of the Equipment Transfer Facility. Material in the transfer boxes may be further staged at a sorting station located nearby. No additional containment structures (tents, etc.) are assumed for this activity; however, like the demolition itself, misting, water, and fixatives will be used to minimize airborne contamination spread. All sorting will only occur when sustained wind speeds are less than 20 miles per hour.

A.1.3 Shearing Damage Ratio

Mechanical shears or mechanical hammer will be used to demolish the penthouse and outer portions of the 236-Z structure. The radioactive material at risk (MAR) is assumed to be evenly distributed over the entire contaminated area being worked on (wall segment, etc.). The damage ratio (DR) is that portion or percentage of the contaminated area acted on by the shear force, or the portion or percentage of the contamination acted on by shear forces. Shears or mechanical hammer are assumed to fracture, crush, spall, or otherwise impact the surface being sheared. The fraction of surface rubblized during shear operations is taken to be 0.9.

The effectiveness of the fixative on the rubblized material (approximately 90% of the sheared material) will conservatively be considered totally lost (i.e., all of the contamination on these pieces will be considered removable). The fixative covering the larger pieces (approximately 10% of the sheared material, essentially all of the cut material) will be considered largely intact and remain effective. All of the material cut by shears or mechanical hammer will be piled on the ground until placed in the ERDF boxes. Approximately 90% of the sheared material will be subject to resuspension as rubble, while 10% will be subject to resuspension as larger pieces. The large panels will have minimal resuspension.

The rubble material will be subject to resuspension processes while lying on the ground. Water sprays will be used during work; a layer of fixative will be applied during interim periods.

A.1.4 Shearing Airborne Release Fraction

DOE's factors for impaction stress due to vibration shock were selected as the most representative release fractions for the crushing processes; the factors selected were 0.001 for removable contaminants and one-tenth that (0.0001) for fixed contaminants (DOE 1994). The EPA's (EPA 1995) compilation of airborne release fractions includes a range of uncontrolled release fractions for crushing of ores and rocks that range from 0.012 to 6 pounds per ton of ore, which relates to an ARF of 6×10^{-6} to 3×10^{-3} – these ranges overlap, supporting the selection of the DOE values.

Fixatives, as the name implies, serve to fix contamination to the surfaces where it is found. In most instances, the contamination particulates become integral with the fixative as opposed to merely being shielded or covered. Fixatives are extremely effective in preventing the migration of contamination from surfaces experiencing little or no traffic. When used during demolition, however, one must consider the impact of the demolition method on the fixative surface structure (e.g., the propensity of the demolition method to produce airborne particulates of the fixative surface containing radioactive contaminants). In this analysis, fixatives are assumed to reduce the production of airborne particulates on surfaces not directly involved with the shearing or cutting processes; however, the shearing process breaks up the material so severely that fixatives are assumed to be only 10% effective for concrete shears or mechanical hammer.

Surfaces not directly impacted by cutting will be disturbed from a variety of sources, including the cutting process (especially for shear cutting), movement and placement of material, general shaking of the building surface, vibrations from heavy equipment, and vibration from fall of rubble to the floor surface. Releases from these surfaces will be controlled by existing fixative, periodic application of fresh fixative, continually wet surfaces, and water spray/mist in the air. These controls are assumed to be sufficient to prevent any emissions from vibration of noncontact surfaces.

As the material falls to the ground from the elevated location on the walls where it originates, it will be subject to entrainment in the air. The EPA considers its emission factor equation for aggregate-handling and storage piles to be applicable to the drop of bulk material onto piles (adapted from EPA 1995):

$$ARF_{DROP} = 1.6x10^{-6} ((WS/2.2)^{1.3}) / ((M/2)^{1.4}))$$

where: WS = characteristic wind speed over drop of material (m/s) - A characteristic wind speed for rubble drop was calculated using a characteristic wind speed for the site estimated by examining a wind climatology from the Hanford Site. A compilation of average wind speeds was provided in the climatology. The ARF is more influenced by periods of higher winds (such as wind gusts). The characteristic wind speed for rubble-handling was estimated to be 3.2 m/s (AlphaTRAC 2003); the result is not sensitive to this assumption. Further conservatism was incorporated because the shielding effect of the building walls and the shielded flow around the other PFP buildings are not considered.

M = moisture value associated with dry material (control effectiveness of water spray handled separately) (%). Because water spray and mist are applied to the pile, a moisture value of 2% for a wet construction aggregate was chosen, based on past experience. Small changes in assumed moisture content result in large variation of the resulting ARF, the ARF decreases more than exponentially with M; the 2% value selected is believed to be conservatively low, resulting in a calculated ARF that should overestimate the releases via this route.

The EPA equation includes a particle-size multiplier ranging from about 0.1 to 0.8. For this analysis, this was conservatively set to 1.0 for all particle sizes. Using these values, the ARF for rubble-handling is estimated to be 2.3×10^{-6}.

Surfaces exposed to the atmosphere between shifts will be subject to resuspension processes. A fresh coat of fixative will be applied to all exposed surfaces (covering any gaps and material deposited on the existing fixative) at the end of demolition operations for a day. Therefore, it is assumed that there is no significant resuspension between shifts.

A.1.5 Leak Path Factor

The LPF is the fraction of the radionuclides in the aerosol transported through some confinement deposition or filtration mechanism. For the purpose of this study, the LPF is used to address any controls applied during and after the demolition process. This includes the effects of water mists, sprays, and fixatives applied to surfaces and rubble after demolition.

The application of a water mist to contaminated surfaces during demolition serves to reduce the percentage of airborne particulates in the respirable size range. The efficiency of the mist varies with each application and depends on, among other variables, mist particle size, water flow rate, and the size of potential airborne particles. For the purposes of this analysis, water-mist application is assumed to reduce the quantity of airborne particulates by 90%. The efficiency of the water-mist process must be weighed in light of the generated waste stream and the need to confine and capture runoff from the misting process. Thus, the LPF for concrete crushing is assumed to be 0.1. This value is slightly lower than that used for the 233-S building (0.3), based on observations of the effectiveness of the misting on that facility[(1)] and during demolition of 232-Z.

As the material falls to the ground and is entrained in the air, a separate LPF may be used. The EPA has published size-specific control-effectiveness values for mist eliminators. The values for < 250 FPM mist eliminators is used to represent the water/mist spray controls applied to materials-handling operations at the 236-Z building. The EPA control-effectiveness values as presented were interpolated to the particles' size ranges identified for this source type. The maximum reported control-effectiveness was assumed for particle sizes larger than those reported in the reference, rather than extrapolating upward from the EPA values. The following LPFs result (EPA 1995):

- 0 – 2.5 μm: 0.95
- 2.5 – 5 μm: 0.60
- 5 – 10 μm: 0.30
- 10 – 15 μm: 0.25
- 15 – 30 μm: 0.25
- > 30 μm: 0.25

A.1.6 Respirable Fraction

The RF is the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system. The RF is assumed to include particles 10-μm AED and less. In this study, all of the suspendable material is addressed (not just the respirable portion). It is estimated that most radioactive particles in the contamination are respirable in size. In this study, the radioactive particles are considered bound to particles of dust from the rubble and are transported as a size distribution of particles representative of construction dust. These particulates are removed from the plume and placed on the ground through dry deposition, a process that removes nonrespirable particles much more effectively than respirable particles. It is conservatively assumed that all radioactive particles separate from any associated rubble particles upon entry into the respiratory system. The result of these considerations is that radioactive particles are modeled to transport as a mixture of particle sizes representative of dust from the rubble and are modeled to impact the respiratory system as all respirable particles.

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(1) Private communication with Dan Mantooth, 26 May 2004. A continuous application of water from an atomizer (e.g., a "fog cannon") is assumed.

A particle-size distribution is given by EPA for conventional aggregate-handling and storage piles (EPA 1995):

Diameter	Percent of Mass
0 – 2.5 µm:	11%
2.5 – 5 µm:	9%
5 – 10 µm:	15%
10 – 15 µm:	13%
15 – 30 µm:	26%
> 30 µm:	26%

A shift in particle size distribution is expected to occur as a result of the mitigation actions. The planned demolition activities include the use of very effective mitigation techniques for capturing the dust that is generated by these operations; only a very small fraction of the dust generated will be released from the demolition activity. There will be a heavy reliance on misting and spraying to both keep the surfaces wet and to scavenge any dust that is generated. Water droplets are well known to be highly effective in removing larger particles and to be very ineffective in removing smaller particles (Slinn 1984). The collection efficiency differences for small droplets changes by almost four orders of magnitude between 1 and 10 micron particles. Assuming that the mitigation will only be an order of magnitude more effective for the larger particles, the particle-size distribution for materials from the demolition activities becomes:

Diameter	Percent of Mass
0 – 2.5 µm:	72%
2.5 – 5 µm:	24%
5 – 10 µm:	2%
10 – 15 µm:	0.9%
15 – 30 µm:	0.17%
> 30 µm:	0.17%

The revised size distribution values listed above are AERMOD input parameters that are used for transport and deposition computations. This adjustment in the size-distribution towards smaller particles will reduce the modeled deposition by about an order of magnitude immediately downwind of the demolition activity and increase the modeled deposition at extended distances. The change also will result in slightly higher modeled airborne exposure rates. This change is supported by the observation that the deposition rates in the vicinity of the demolition activity were being over-predicted by at least an order of magnitude in a previous similar modeling effort (Droppo et al. 2007). Given the very large experimental differences in collection efficiencies, the actual shift to smaller particles may well be much greater that the assumed order of magnitude shift. However with the lack of experimental data to confirm such a large shift in the particle-size distribution, any larger factor to account for this process other than that supported by the previous modeling effort is felt to be inappropriate.

A respirable fraction of 1.0 is applied in the Source Term equation because the removal of nonrespirable particles from the plume is treated separately as a transport and dispersion function within the AERMOD modeling, and only about 1% of the particles escaping are greater than 10 µm in diameter.

A.1.7 Surgical Removal of Equipment

Equipment to remain in the 236-Z Building includes gloveboxes, filter boxes, pipes, and galleries. Prior to demolition of the building, it is assumed that the equipment will be prepared and slightly "hardened" to protect it and minimize releases. For hoods, filters, and piping, it is assumed that the equipment will be covered with fixative to fill voids and cover internal surfaces. Ports and windows will be covered with metal plates to prevent fracturing them when nearby walls and ceilings are removed with shears or mechanical hammer. They may also be wrapped in plastic sheeting. Minor damage from falling materials is assumed to dent and rip portions of the protective coverings – a damage ratio of 1 percent. A release fraction of $1x10^{-6}$ is assumed for the contents of the equipment. Because water sprays will be used, a leak path factor of 0.1 is assumed. When combined, this results in an emission factor of $1x10^{-9}$ for this type of equipment.

The galleries on the 1st and 2nd stories of the 236-Z are a special case. The galleries are 304L stainless steel boxes affixed to the outer walls of the process cell. These galleries have a large estimated inventory of plutonium contamination. Most of the internal contamination appears to be chemically fixed to the metal lining of the galleries. It is assumed that the inner and outward-facing external surfaces will be covered by a rubberized fixative "FireDam-200" (described at http://multimedia.3m.com/mws/media/373702O/3mtm-firedamtm-spray-200-brochure.pdf and viewable on YouTube). The galleries may be pre-cut so that only small tabs of metal hold them together prior to the demolition of the surrounding structure, or they may be separated using shears via penetration through the diamond-shaped windows. When they are exposed, this will allow them to be gripped by the multiprocessor and pulled off of the cell outer walls.

For the galleries, it is assumed that:

- The fixative prevents suspension from intact surfaces
- Gripping/pulling by hydraulic equipment scratches/gouges ~1% of surface (equivalent to 2 deep scratches 1 cm x 50 cm per square meter). This gives a damage ratio of 0.01 for gallery detachment.
- 95% of Pu material is fixed "pickled" to surface, for this an airborne release fraction of $1x10^{-4}$ is used.
- 5% of Pu material is loose, for this an airborne release fraction of $1x10^{-3}$ is used.
- The material released is in small particles, so the respirable fraction is 1.0.
- Water sprays are as effective as normally assumed, resulting in a leak path factor of 0.1.

As a result of these assumptions, the emission factor for materials in the galleries is assumed to be $1.45x10^{-7}$. Note that the galleries are affixed/grouted to the back walls (the outer walls of the process cell), which have been assumed to be contaminated to an average level of 25 nCi/gram of alpha-emitting radionuclides. Ripping the galleries off of the wall will result in spalling the entire surface. Each of the four galleries is about 8 feet tall and 65 feet long. Preliminary calculations indicate that the amount of material made airborne in this activity could be nearly 30 grams of concrete dust, which would contain about 3 µCi of alpha-emitting radionuclides. This would be a small fraction of the total release, so this process has been omitted in the calculations.

A.2 The 242-Z Waste Treatment Facility

The 242-Z Waste Treatment Facility began operation in 1963 to recover plutonium from aqueous waste streams from the PFP. An ^{241}Am recovery process was installed in a glovebox in 242-Z and began operation in May 1965. The recovery process was converted from batch to continuous in 1969. In April 1976, the 242-Z facility was shut down as a result of a labor strike. In August 1976, during restart of the americium recovery process, an explosion occurred in a cation ion exchange column that contained approximately 100 g of ^{241}Am. This resulted in substantial americium internal exposure to a worker and extreme contamination to most of the building. As a result, the 242-Z facility was permanently closed. Gross contamination from the explosion was removed. Doors into the operating area were welded shut and re-entry into the facility for final cleanup only began in April 2010.

The 242-Z facility was a 1000-square-foot building located on the south side of the southeast corner of the 234-5 building. It was 40 feet wide, 26 feet long, and 23 feet high (Figure A.1). The south portion of the building was 40 feet wide and 10 feet long and consisted of a tank room (tank cell). This room extended the full inside building height. The north portion was designated the control room, and had a mezzanine over its west half for chemical addition tanks. The building was constructed of structural steel with an aluminum panel outer sheath, rock wool insulation and 16-gauge sheet steel. The floor was concrete and the south wall was reinforced concrete. The rest of the building had plaster inside and insulating material wall panels outside. The roof was slightly peaked and composed of metal decking covered by insulation and built-up asphalt and gravel.

There is an annex on the west side of the building that allows access to 234-5. This annex was entered by three people immediately following the accident, who noticed the door open to the operating/control room and left immediately; they were found to be contaminated. It will be assumed that there is some level of contamination in the annex. The operators and HPs exited via the enclosed hallway on the east side of the building; this will also be assumed to be contaminated to a low level.

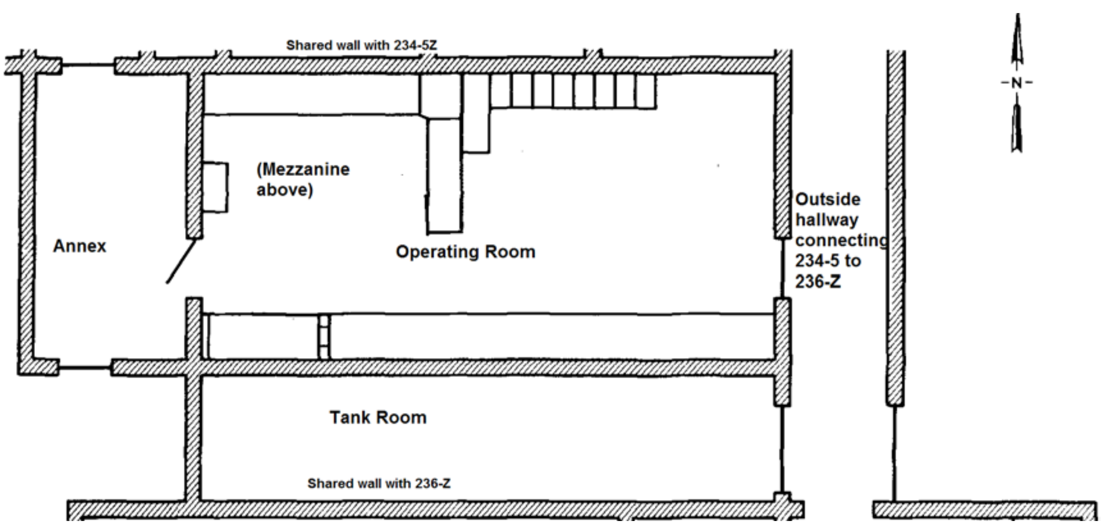


Figure A.1. Floor Plan of the 242-Z Building and Nearby Structures

Contamination in the 242-Z facility is extensive. Hoyt and Teal suggested a total of 10 grams of Pu mixture in the building, excluding residual americium from the explosion. If it is assumed that 99% of the ^{241}Am has been recovered, there is still 1 gram of ^{241}Am remaining. Combined, this would be over

5 alpha curies of radioactive materials. Materials supplied by Oldfield and Sauer (workbook dated 3 November 2015) indicate the contamination levels to be the following:

		Contaminated Surfaces			*Strategic Removals*		
Zone	**Location**	**Debris Wt (lb)**	**Area (SF)**	**dpm/100cm^2**	**QTY**	**Unit**	**TRU Pu (g)**
SZ-1	242-Z and 242-ZA	**289446**	**9200**	4.10E+06	9	Tanks	532

CHPRC staff have suggested that the 9 tanks from the tank room will be carefully removed during the demolition of the structure by opening a wall at one end and moving them out. The 9 tanks are:

Tank ID	PU (grams)
W-1	18
W-2	166
W-3	19
W-4	18
W-5	122
W-6	32
W-12E	77
W-12W	76
W-15	4

CHPRC staff have recommended that all facilities will be cleaned up to a minimum of 10,000 dpm/100 cm^2 for "light contamination" areas and 2,000,000 dpm/100 cm^2 for "heavy contamination" areas. For the purposes of this analysis, the operating/control room and tank room are assumed to have "heavy" contamination, and the annex and outside hallway are assumed to have "light" contamination. Contaminated areas, exclusive of removed equipment, are listed in Table A.1. The material in Table A.1 was modified from that provided by CHPRC to enable detailed analyses of the various components; total areas and contamination levels are the same. The nature of the activities in the 242-Z building supports the idea that the material in this building is largely in soluble nitrate forms.

Table A.1. Contamination Levels Assumed in Portions of 242-Z at Demolition

Building Zone	Area (ft^2)	Approximate mass (grams)	Contamination (dpm/100 cm^2)	Inventory (alpha curies)
Control room walls	3070	5.70E+07	6,500,000	8.35E-02
Control room ceiling	730	1.24E+07	6,500,000	1.99E-02
Tank room walls	2590	2.83E+07 (1)	3,900,000	4.23E-02
Tank room ceiling	410	6.94E+06	3,900,000	6.99E-03
Annex walls	1175	1.72E+07 (2)	100,000	4.92E-04
Annex ceiling	325	5.50E+06	100,000	1.36E-04
Hall walls	590	5.59E+06 (3)	2,000	4.94E-06
Hall ceiling	210	3.56E+06	2,000	1.76E-06
Totals	9100	1.31E+08		0.15

(1) excluding common wall with control room and tank room
(2) excluding common wall with control room
(3) excluding common walls with 236-Z building and control room

A.2.1 Demolition Schedule

The demolition schedule is defined to require 7 working days. The 242-Z building is a small, metal-frame building. The assumed schedule is provided in Table A.2.

Table A.2. Demolition Schedule

Day	Building Location
1	West annex
2	East hallway/Pull tanks
3	Roof
4	South wall (residual part of 236Z)
5	East wall
6	Center wall
7	West wall
	(Leave north wall as part of 234-5Z)

A.2.2 Demolition Approach

The building roof and walls are assumed to be demolished with a multiprocessor operating hydraulic shears or mechanical hammer end effectors. The walls are to be demolished from the top down, using a large excavator to manipulate the multiprocessor. This device will rip the metal sheeting and separate the steel framing. Misting, water, and fixatives will be used throughout the demolition process and load out to minimize airborne contamination spread. All demolition will only occur when sustained wind speeds are less than 20 miles per hour.

It is assumed that the lesser-contaminated outer structures (annex, eastern outside hallway) are removed first, with a portion of the roof of the tank room. Upon opening of the east hallway, the tanks will be removed through the open wall.

For structural reasons, it is assumed that remainder of the ceiling/roof is removed. The floor of the building is assumed to be covered with sand (or a similar substance) to absorb the impact of falling debris and to minimize suspension of floor contamination. This action opens the main room to the atmosphere for the remainder of the demolition. The walls are removed in a logical order allowing access. The final wall shared with 234-5Z is left and removed with that building.

A.2.3 Damage Ratio

Mechanical shears or mechanical hammer are assumed to be used to demolish the 242-Z structure after it has been extensively prepared. The radioactive material at risk (MAR) is assumed to be evenly distributed over the entire contaminated area being worked on (wall segment, etc.). The damage ratio (DR) is that portion or percentage of the contaminated area acted on by the shear force, or the portion or percentage of the contamination acted on by shear forces. Shears or mechanical hammer are assumed to fracture, crush, spall, or otherwise impact the surface being sheared. The fraction of surface from which paints/fixatives are assumed to be removed (scratched, peeled) during shear operations is taken to be 0.1.

A.2.4 Airborne Release Fraction

DOE's factors for impaction stress due to vibration and shock for materials that do not brittle fracture (e.g., ductile metal sheeting) were selected as the most representative release fractions for the crushing processes; the factors selected were 0.001 (DOE 1994, Section 5.3.3.2.2) for removable contaminants and 0.00001 (based on one percent of 0.001) for contaminants with a double layer of paint/fixative (TRUTech 2001).

Surfaces not directly impacted by cutting will be disturbed from a variety of sources, including the cutting process (especially for shear cutting), movement and placement of material, general shaking of the building surface, vibrations from heavy equipment, and vibration from fall of rubble to the floor surface. Releases from these surfaces will be controlled by existing fixative, periodic application of fresh fixative, continually wet surfaces, and water spray/mist in the air. These controls are assumed to be sufficient to prevent any emissions from vibration of noncontact surfaces.

As the material falls to the ground from the elevated location on the walls where it originates, it will be subject to entrainment in the air. The EPA method described in Section A.1.4 is used. Because sheet metal is less likely to be dusty than pulverized concrete rubble, the results of this calculation were reduced to $1x10^{-6}$ for application to 242-Z. In addition, this release fraction is applied only to the 10% of the material that has had the fixatives damaged.

Surfaces exposed to the atmosphere between shifts will be subject to resuspension processes. A fresh coat of fixative will be applied to all exposed surfaces (covering any gaps and material deposited on the existing fixative) at the end of demolition operations for a day. Therefore, it is assumed that there is no resuspension between shifts.

A.2.5 Leak Path Factor

The LPF is the fraction of the radionuclides in the aerosol transported through some confinement deposition or filtration mechanism. For the purpose of this study, the LPF is used to address any controls applied during and after the demolition process. This includes the effects of water mists, sprays, and fixatives applied to surfaces and rubble after demolition.

The LPF for shearing is assumed to be 0.1, as discussed in Section A.1.

A.2.6 Respirable Fraction

As discussed in Section A.1, a respirable fraction of 1.0 is applied in the Source Term equation because the removal of nonrespirable particles from the plume is treated separately as a transport and dispersion function within the AERMOD modeling.

A.2.7 Surgical Removal of Equipment

As discussed for 236Z, the tanks will be removed as intact units. The emission factor developed for equipment of $1x10^{-9}$ is used for the tanks.

A.3 234-5Z Building

The 234-5Z building is approximately 152 m (500 ft) long and 55 m (180 ft) wide. The floor levels are the basement, first story, duct level, and second story. The frame is structural steel with an outer sheathing of aluminum panels over rock wool insulation and 16-guage sheet metal. There are also 20 cm (8 in) thick interior reinforced concrete walls, principally running in the east-west direction, and two box-type reinforced concrete stairwells. The stairwells extend to the roof; the reinforced concrete walls stop at the second floor. Contamination levels are quite variable within this large structure; the bulk of residual contamination is expected to reside in the central core and on the duct level.

Staff of CHPRC have proposed levels of contamination that could remain following planned ongoing cleanout operations for this building (workbook of 3 November 2015 provided by Sauer). The old Recuplex area (current HP office), RMA and RMC lines will be assumed to be at 200,000 dpm/100 cm^2. This is the area between columns C-E north/south and 4-18 east/west. This is assumed to continue up into the "Duct Level" because these rooms extend up this high with overlooking mezzanines, etc.

Figure A.2. 234-5Z Building Under Construction, Showing Steel Structure. Building column grid A-J (omitting I) is from right to left in this photo; column lines 1-24 begin at this eastern end and work toward the west. The 242-Z and 236-Z buildings had not been started when this photo was taken.

The area used as the analytical laboratory will be assumed to be at 20,000 dpm/100 cm^2. This is the area between columns E-J north/south and 1-7 east/west. The area that in later years was the development laboratory will be assumed to be at 20,000 dpm/100cm^2. This is roughly the area between columns E-G north/south and 7-22 east/west, and includes the southern office annex. The average of "the rest of the building surfaces" will be taken as 1/10th of 20,000 dpm/ 100cm^2 = 2000 dpm/100cm^2.

These areas are illustrated in the idealized plan view of the building shown in Figure A.3.

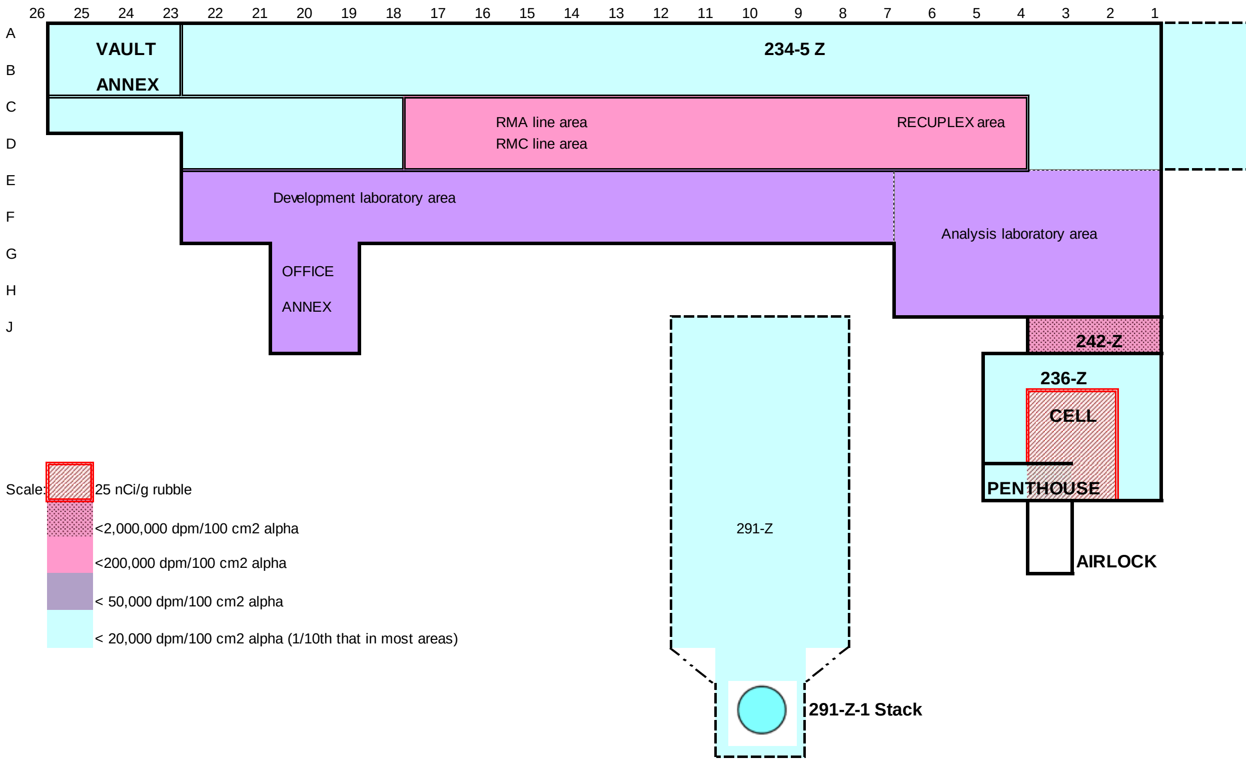


Figure A.3. Contamination Levels in the PFP Complex

A.3.1 Demolition Schedule

An approximate schedule for demolition has been prepared by CHPRC to allow calculations. The building has been divided into "demolition zones." It is assumed that demolition will be completed by zone; additional work will be required to load the rubble into ERDF containers before demolition can commence on the subsequent zone. The demolition zones assumed are illustrated in Figure A.4. The schedule that results from these assumptions is given in Table A.3.

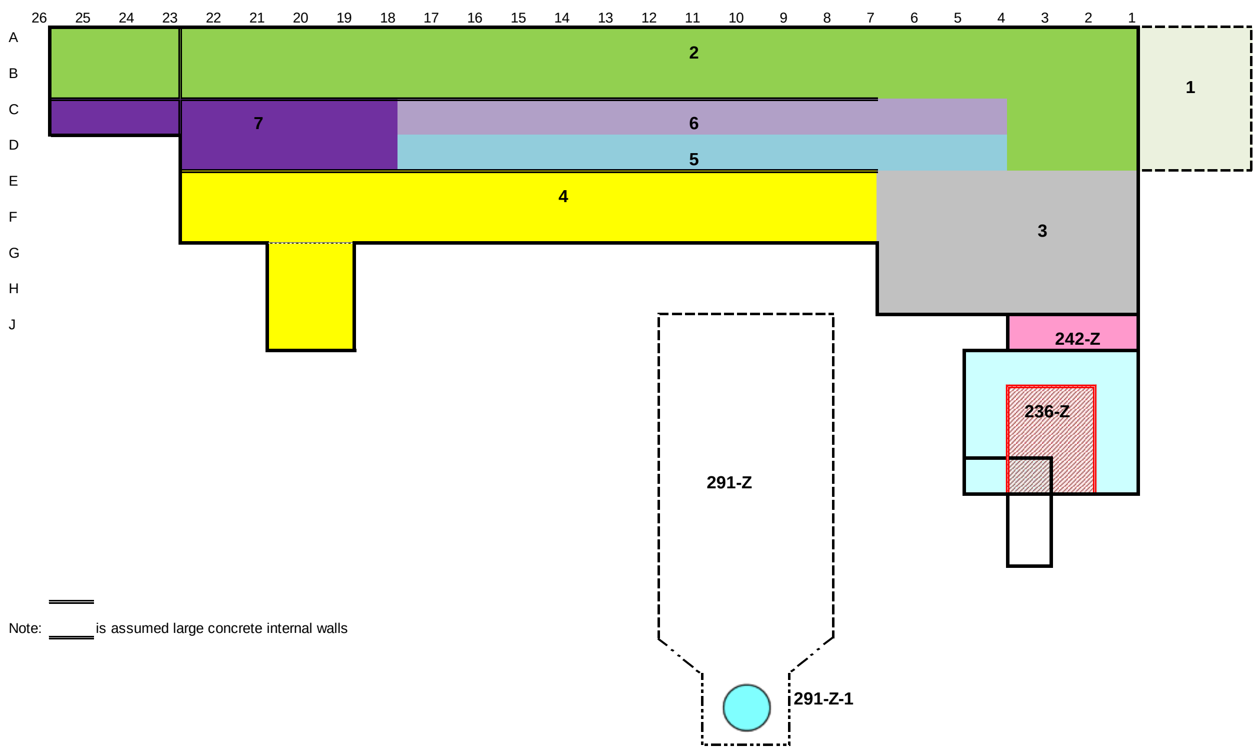


Figure A.4. Demolition Zones Assumed for Analysis

Table A.3. Demolition Schedule for 234-5Z

ZONE:	Area/Glovebox	Day	Swing	
1	Office area	2	2	Shifts
2	North Face	12	12	Shifts
3	Analysis lab area	9	9	Shifts
	145-1, Rm 262 Filter boxes (14)	1	1	Shifts
4	South face	16	16	Shifts
	159-1; 159-2; Pencil tanks; Rm 262 Filter boxes (13)	2	2	Shifts
5	RMC Line	7	7	Shifts
	HC-227-S; HC227-T; HC-18M, Rm 263 Filter boxes (6)	1	1	Shifts
	1000 LF Ductwork	1	1	Shifts
6	RMA Line	7	7	Shifts
	HA-46, Vac Pump 10/11, Rm 254 Filter boxes (4)	1	1	Shifts
7	Metalworking Area	8	8	Shifts
	GB-100B, GB-200, GB-300, Rm 235D filter boxes (3)	1	1	Shifts
	Tunnel Drain lines (8 sets in 6 tunnels)	1	1	Shifts
	Subtotal	69	69	Shifts

A.3.2 Demolition Approach

It is assumed that the lesser-contaminated outer structures (office area) are removed first.

The building roof and walls are assumed to be demolished with a multiprocessor operating hydraulic shears or mechanical hammer end effectors. The walls are to be demolished from the top down, using a large excavator to manipulate the multiprocessor. This device will rip the metal sheeting, rubblize the lath and plaster walls, and separate the steel framing. Misting, water, and fixatives will be used throughout the demolition process and load out to minimize airborne contamination spread. All demolition will only occur when sustained wind speeds are less than 20 miles per hour. It is assumed that the steel structure will be the final portion of each zone removed, in a manner similar to recent demolition of the 212-R building at Hanford, as illustrated in Figure A.5. The piles of rubble will be sorted into ERDF boxes and removed; during the next zone demolition, the ERDF boxes will be placed in locations on the floor of the prior zone for loading.

Figure A.5. Assumed Interim Demolition Conditions: Roof and Walls Rubblized Prior to Shearing of Steel Framework (212-R building used as example)

A.3.3 Damage Ratio

The external walls of the 234-5-Z building are aluminum panels with insulation and a thin steel inner liner. These external wall panels will not be extensively contaminated from historical operations. The mass of the wall panels is about 5 pounds/ft^2. The inner building walls are lath-and-plaster construction. Lath-and-plaster as applied in the late 1940s was a sand-cement layer mortared onto extruded metal mesh.

Mechanical shears or mechanical hammer are assumed to be used to demolish the 234-5-Z structure. The radioactive material at risk (MAR) is assumed to be evenly distributed over the entire contaminated area being worked on (wall segment, etc.). The damage ratio (DR) is that portion or percentage of the contaminated area acted on by the shear force, or the portion or percentage of the contamination acted on by shear forces. Shears or mechanical hammer are assumed to fracture, crush, spall, or otherwise impact the surface being sheared. The fraction of surface from which paints/fixatives are assumed to be removed (scratched, peeled) during shear operations is taken to be 0.9.

The effectiveness of the fixative on the rubblized material (approximately 90% of the sheared material) will conservatively be considered totally lost (i.e., all of the contamination on these pieces will be considered removable). The fixative covering the larger pieces (approximately 10% of the sheared material, essentially all of the cut material) will be considered largely intact and remain effective. All of the material cut by shears or mechanical hammer will be piled on the ground until placed in the ERDF boxes. Approximately 90% of the sheared material will be subject to resuspension as rubble, while 10% will be subject to resuspension as larger pieces.

DOE's factors for impaction stress due to vibration and shock for materials that do not brittle fracture (e.g., ductile metal sheeting) were selected as the most representative release fractions for the crushing processes; the factors selected were 0.001 (DOE 1994) for removable contaminants and one percent of that (0.00001) for contaminants with a double layer of paint/fixative (TRUTech 2001).

Surfaces not directly impacted by cutting will be disturbed from a variety of sources, including the cutting process (especially for shear cutting), movement and placement of material, general shaking of the building surface, vibrations from heavy equipment, and vibration from fall of rubble to the floor surface. Releases from these surfaces will be controlled by existing fixative, periodic application of fresh fixative, continually wet surfaces, and water spray/mist in the air. These controls are assumed to be sufficient to prevent any emissions from vibration of noncontact surfaces.

As the material falls to the ground from the elevated location on the walls where it originates, it will be subject to entrainment in the air. The EPA method for determining the airborne emission rate is that described in Section A.1.4. Because sheet metal is less likely to be dusty than pulverized concrete rubble, the results of this calculation were reduced to 1×10^{-6} for application to 234-5Z. In addition, this release fraction is applied only to the 90% of the material that has had the fixatives damaged.

Surfaces exposed to the atmosphere between shifts will be subject to resuspension processes. A fresh coat of fixative will be applied to all exposed surfaces (covering any gaps and material deposited on the existing fixative) at the end of demolition operations for a day. Therefore, it is assumed that there is no resuspension between shifts.

A.3.4 Leak Path Factor

The LPF is the fraction of the radionuclides in the aerosol transported through some confinement deposition or filtration mechanism. For the purpose of this study, the LPF is used to address any controls applied during and after the demolition process. This includes the effects of water mists, sprays, and fixatives applied to surfaces and rubble after demolition.

The LPF for shearing is assumed to be 0.1, as discussed in Section A.1.

A.3.5 Respirable Fraction

As discussed in Section A.1, a respirable fraction of 1.0 is applied in the Source Term equation because the removal of nonrespirable particles from the plume is treated separately as a transport and dispersion function within the AERMOD modeling.

A.3.6 234-5Z Building Surface Areas

Using cleanup criteria based on dpm/100 cm^2 within the building is a simple approach to determining residual contamination. The total inventory of potentially releasable material must then be based on the total surface area of each demolition zone. The total surface areas were estimated on the basis of detailed drawings of the building. Contamination levels, contaminated area, and rubble mass were provided by the CHPRC team of Oldfield and Sauer (workbook dated 3 November 2015). The various demolition zone characteristics are summarized in Table A.4.

Table A.4. Descriptions of the Demolition Zones for the 234-5Z Building

Zone No.	Description	Glovebox contents (grams Pu)	Cont. Level (dpm/100 cm2) (Alpha)	Surface Area (Square ft)	Mass (lb)	Inventory (alpha Ci)
1	Uncontaminated offices		2000	1000	262335	0.00001
2	North Face					
	1st storey		2000	10000	5319554	0.00008
3	Analysis lab area					
	Surfaces		20000	117344	2233034	0.01
	145-1	3				0.35
	Rm 262 Filter Boxes	26				3.07
4	South face					
	Surfaces		20000	196364	3323369	0.02
	Upper pencil tank	166				19.59
	Lower pencil tank	98				11.57
	159-1	1				0.12
	159-2	1				0.12
	Rm 262 Filter boxes	284				33.52
5	RMC Line					
	Surfaces		200000	105384	1545479	0.09
	HC-227-S	30				3.54
	HC-227-T	30				3.54
	HC-18M	76				8.97
	Rm 263 Filter Boxes	98				11.57
	1000 LF Ductwork	50				5.90
6	RMA Line					
	Surfaces		200000	99908	1676105	0.08
	HA-46	1				0.12
	Vacuum Pump Cols	2				0.24
	Rm 254 Filter boxes	34				4.01

Zone No.	Description	Glovebox contents (grams Pu)	Cont. Level (dpm/100 cm2) (Alpha)	Surface Area (Square ft)	Mass (lb)	Inventory (alpha Ci)
7	Metalworking Area					
	Surfaces		20000	72496	1510281	0.01
	GB-100B	1				0.12
	GB-200	1				0.12
	GB-300B	1				0.12
	Rm 235D Filter Boxes	21				2.48
	Tunnel piping	550				64.92

A.4 291-Z Fan House and Stack

The 291-Z building houses the final exhaust plenum, fans, and 200-foot discharge stack for the 234-5Z (PFP), 232-Z (incinerator – previously decommissioned), and the 236-Z (plutonium reclamation) buildings. Exhaust from the three facilities enters a large (15-ft x 20-ft) central concrete plenum. Several stainless steel centrifugal fans located on both sides of this central plenum draw air from the central plenum and move the air into two lower plenums on each side of the central plenum below the fans. The two plenums join together downstream of the fans at a **V** shape junction and the combined flow enters the base of the 291-Z-1 stack (Figure A.6). The stack is a concrete structure 200 f t high with an inside diameter of 16.5 feet at the base and 13.5 feet at the top. An access door is located near the base of the stack, and a sampling system with constant air monitors (CAMs) that alarm at pre-set levels and record samplers for data collection is located at the 50-foot level. The stack was designed to have the entire interior surface receive two coats of paint.

The 291-Z-1 stack, attached to the 291-Z building, began operation in 1949. Residual contamination is assumed to be covered with fixatives inside the stack.

The residual contamination levels provided by the CHPRC Team (Oldfield and Sauer, workbook dated 3 November 2015) are listed below:

	Location	Debris Wt (lb)	Area (SF)	dpm/100 cm^2	QTY	Unit	Pu (g)
SZ-1	291-Z Fanhouse	5314936	12000	2000	724	LF 26" PV Lines	502
SZ-2	291-Z-001 Stack	937365	9000	3000	None		

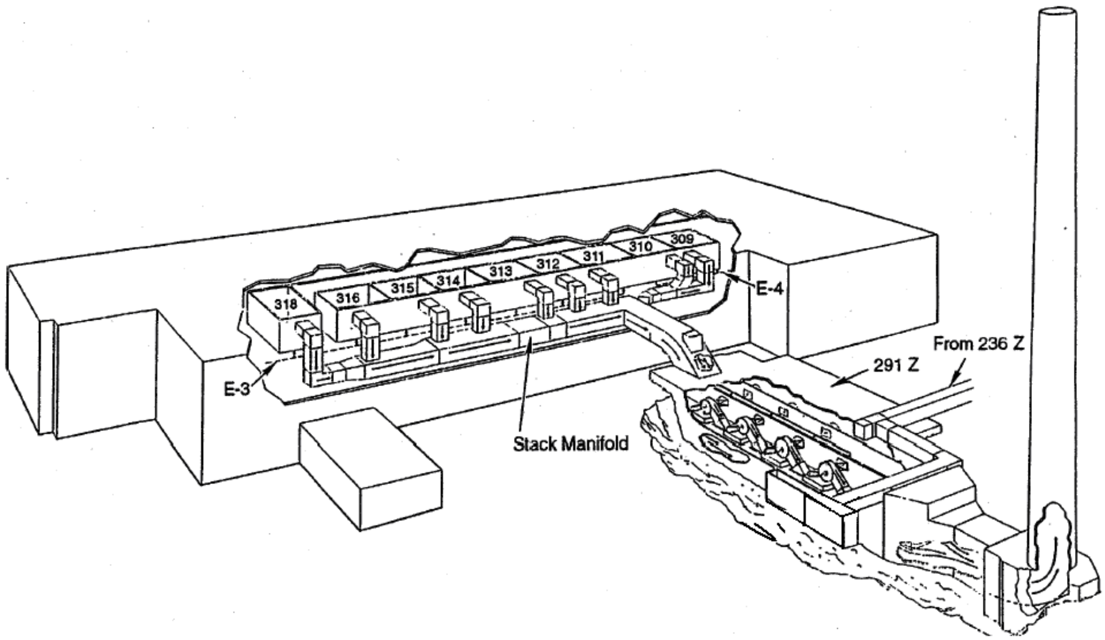


Figure A.6. Cutaway View of 234-5Z and 291-Z Ventilation Exhaust System , including 291-Z-1 stack (adapted from Mahoney et al. 1994)

A.4.1 Demolition Schedule

The demolition schedule was provided by CHPRC staff. The demolition of the fanhouse is assumed to require 18 days. Details of the demolition are provided in Table A.5.

Table A.5. Demolition Schedule for 291-Z

	Demo/day	Loadout/swing
Remove roof of Rms 500, 501	3	3
Room 501 Vacuum pump inlet: 73'	1	
Room 501 Vacuum pump exhaust: 37'		1
Remove roof of Rms 502, 503, upper plenum	2	2
6" East Vacuum Line 89'	1	1
4" East Process Vacuum Line to Room 501: 74'	1	
4" Process Vacuum Line 36.5'		1
6" West Vacuum Line 100'	1	
4" West process vacuum line east fan gallery to 501: 79'		1
6" process vacuum Line 11.5'	1	
6" Sample vacuum line by filters : 12'		1
Demolish mid-section of plenum to access bottom	2	2
6" top process vacuum line in plenum : 53'	1	1
4" east process vacuum line in plenum: 53'		1
4" west process vacuum line in plenum: 53'	1	
6" bottom process vacuum line in plenum : 53'	1	1
Demolish remaining above-ground portions	3	3

The 291-Z-1 stack is a 200-foot-tall, slip-formed reinforced-concrete structure. Most similar large stacks at Hanford have been removed by explosive demolition, toppling the more-or-less intact stack to the ground and then disposing of the pieces at ground level. It is assumed that this will also happen to the 291-Z-1 stack. The assumed schedule is provided in Table A.6

Table A.6. Demolition Schedule for 291-Z-1

Day	Building Location
1	Topple stack
2-15	Size-reduce concrete
2-15	Load rubble into ERDF boxes

A.4.2 Demolition Approach

For the 291-Z fanhouse, demolition is assumed to be conducted with a hydraulic shear or mechanical hammer mounted on a tracked vehicle. The roofs of the eastern rooms 500 and 501 are assumed to be removed. The Room 501 vacuum pump inlet and exhaust are assumed to be carefully removed. The roofs of Rooms 502 and 503 and the contiguous upper inlet plenum are removed. A set of seven vacuum lines are carefully removed. The mid-section of the plenum between the inlet and outlet is then sheared and removed, providing access to an additional 4 vacuum lines which are carefully removed. Any remaining above-ground portions of the side walls are then removed.

It is assumed that, after some preparatory weakening of the stack base, a small explosive charge is used to weaken the stack so that it falls into a prepared shallow trench in the neighboring soil. A charge of 5 kg of high explosives is assumed. It is assumed that demolition occurs on a day of “favorable” weather.

When the stack has been brought to ground level, a multiprocessor with jackhammer or shear end effector is assumed to break the reinforced concrete into approximately 1-foot by 1-foot pieces. These pieces and associated rubble are loaded into ERDF boxes located nearby with front-end loaders.

A.4.3 Damage Ratio

Removal of the walls and equipment within the 291-Z fanhouse is performed in accord with the approaches described above for the other PFP structures.

The small portion of the stack at ground level that is cut with explosives will be extensively pulverized. However, only the inner surface is contaminated, so the release of radioactive material will be minimal. It is assumed that the amount of dust generated is 1-for-1 with the mass of HE used (DOE 1994), so about 5 kg of dust will be generated. If the area impacted by the explosion is one-half of the stack circumference to a height of 1 foot, the impacted mass is about 150 lb/ft^3 * 29 feet * 1 foot thick * 1 foot high. The ratio of the dust to the total mass is about 0.0014.

Mechanical shears or mechanical hammer are assumed to be used to demolish the 291-Z-1 stack after it has been toppled. The radioactive material at risk (MAR) is assumed to be evenly distributed over the entire inner surface of the stack. The damage ratio (DR) is that portion or percentage of the contaminated area acted on by the shear force, or the portion or percentage of the contamination acted on by shear forces. Shears or mechanical hammer are assumed to fracture, crush, spall, or otherwise impact the surface being sheared. The damage ratio (DR) is that portion or percentage of the contaminated area acted on by the shear force, or the portion or percentage of the contamination acted on by shear forces. Shears or mechanical hammer are assumed to fracture, crush, spall, or otherwise impact the surface being sheared. The fraction of surface rubblized during shear operations is taken to be 0.5.

The effectiveness of the fixative on the rubblized material (approximately 50% of the sheared material) will conservatively be considered totally lost, i.e., all of the contamination on these pieces will be considered removable. The fixative covering the larger pieces (approximately 50% of the sheared material, essentially all of the cut material) will be considered largely intact and remain effective. All of the material cut by shears or mechanical hammer will be piled on the ground until placed in the ERDF boxes. Approximately 50% of the sheared material will be subject to resuspension as rubble, while 50% will be subject to resuspension as larger pieces.

A.4.4 Airborne Release Fraction

Removal of the walls and equipment within the 291-Z fanhouse is performed in accord with the approaches described above for the other PFP structures.

DOE's factors for impaction stress due to vibration shock were reviewed as the most representative release fractions for the explosive demolition (DOE 1994); the factor of 0.001 is very similar to that derived above of 0.0014 on the basis of dust generation.

DOE's factors for impaction stress due to vibration shock were selected as the most representative release fractions for the crushing processes; the factors selected were 0.001 for removable contaminants and one-tenth that (0.0001) for fixed contaminants (DOE 1994). The EPA's (EPA 1995) compilation of airborne release fractions includes a range of uncontrolled release fractions for crushing of ores and rocks that range from 0.012 to 6 pounds per ton of ore, which relates to an ARF of 6×10^{-6} to 3×10^{-3} – these ranges overlap, supporting the selection of the DOE values.

Surfaces exposed to the atmosphere between shifts will be subject to resuspension processes. A fresh coat of fixative will be applied to all exposed surfaces (covering any gaps and material deposited on the existing fixative) at the end of demolition operations for a day. Therefore, it is assumed that there is no resuspension between shifts.

During loading of rubble into ERDF boxes, as the material falls, it will be subject to entrainment in the air. The ARF for rubble-handling is estimated to be 2.3×10^{-6}, as discussed for similar activities in Section A.1.

A.4.5 Leak Path Factor

Removal of the walls and equipment within the 291-Z fanhouse is performed in accord with the approaches described above for the other PFP structures.

The LPF is the fraction of the radionuclides in the aerosol transported through some confinement deposition or filtration mechanism. For the purpose of this study, the LPF is used to address any controls applied during and after the demolition process. This includes the effects of water mists, sprays, and fixatives applied to surfaces and rubble after demolition.

For the initial explosive puff, no credit is given for water sprays; for this step the LPF is 1.0.

The application of a water mist to contaminated surfaces during demolition serves to reduce the percentage of airborne particulates in the respirable size range. The LPF for shearing is assumed to be 0.1, as discussed for similar activities in Section A.1.

A.4.6 Respirable Fraction

The RF is the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system. A respirable fraction of 1.0 is applied in the Source Term equation because the removal of nonrespirable particles from the plume is treated separately as a transport and dispersion function within the AERMOD modeling.

A.5 References

AlphaTRAC. 2003. *Demolition Scenarios and Source Terms for Atmospheric Modeling*. AlphaTRAC, Inc., 8670 Wolff Court, Suite 120, Westminster, Colorado.

DOE – U.S. Department of Energy. 1994. DOE Handbook, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Volume 1 - Analysis of Experimental Data. DOE-HDBK-3010-94, Washington, D.C.

Droppo JG, Jr, BA Napier, ER Lloyd, DS Mantooth, MJ Minette, and EM Mattlin. 2007. "Operational Limitations for Demolition of a Highly Alpha-Contaminated Building – Modeled Versus Measured Air and Surface Activity Concentrations." In *2007 Midyear Topical Meeting - Decontamination, Decommissioning, and Environmental Cleanup*, January 21 - 24, 2007, Knoxville, Tennessee. PNNL-SA-52608, Pacific Northwest National Laboratory, Richland, Washington.

EPA – U.S. Environmental Protection Agency. 1995. Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume 1: Stationary Point and Area Sources. Research Triangle Park, North Carolina.

Mahoney LA, MY Ballinger, WE Davis, SJ Jette, LM Thomas, JA Glissmeyer. 1994. *Literature Review Supporting Assessment of Potential Radionuclides in the 291-Z Exhaust Ventilation.* PNL-9995, Pacific Northwest Laboratory, Richland, Washington.

Slinn WGN. 1984. "Precipitation Scavenging." Chapter 11 in Atmospheric Science and Power Production, D Randerson, ed., DOE/TIC-27601, U.S. Department of Energy, Washington, D.C.

Teal J, Hoyt R. *Plutonium Finishing Plant Characterization for Demolition Air Modeling Studies,* HNF-26042 Rev 0.

TRUTech. 2001. *Decommissioning Criteria Document for the United States Department of Energy Plutonium Facilities.* TRUTech, L.L.C., P.O. Box 1365, Idaho Falls, Idaho.

Appendix B

Atmospheric Model Selection

Appendix B – Atmospheric Model Selection

Releases of contaminants to the air during the demolition activities described in Appendix A potentially can have impacts in terms of the resulting increases in air and soil concentrations. An atmospheric dispersion modeling analysis has been conducted to generate estimates of these concentrations.

The air dispersion model AERMOD was selected for doing simulations of the potential air and soil exposures from the proposed demolition of the structures at the Plutonium Facility Plant (PFP). The AERMOD modeling system is the preferred/recommended air dispersion model to be used in almost all circumstances, including for State Implementation Plans (SIP) revisions for existing sources and for New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs. In addition to being a recommended model, AERMOD also has modeling capabilities needed to address the dispersion from the proposed demolition of the PFP structures. AERMOD includes formulations for addressing air dispersion in the immediate vicinity of air emission sources. The model has dry deposition algorithms that account for the particle-size distribution and density as well as local surface and meteorological conditions. Important in the selection of AERMOD for this application is its ability to address building wake effects; the current version of AERMOD incorporates the building wake formulations developed by EPRI.

A potential limitation of AERMOD for Hanford applications is the model's use of straight-line trajectories for the modeled airborne plumes. This model feature means that the model cannot account for downwind changes in wind direction. The Hanford Site does have complex wind patterns and AERMOD may not be an appropriate model for modeling potential concentrations at far-field distances (i.e., beyond the Hanford Site boundary). However, AERMOD is quite appropriate for near-field plume simulations being conducted in this effort.

Appendix C

Air Dispersion Modeling Assumptions

Appendix C – Air Dispersion Modeling Assumptions

AERMOD information and documentation is available on the U.S. Environmental Protection Agency's (EPA's) website for regulatory air models (EPA 2008). The most recently released version of AERMOD was used. AERMOD is considered a commercial model. For Hanford Site applications, such a model must be tested to ensure it is operating correctly in its current implementation (Project Hanford Management System 2002). A series of test cases distributed with AERMOD obtained from the EPA website (EPA 2008) was run and compared with the official versions. The AERMOD runs were conducted using a single computer (PNNL property number WE28738) with the Windows 7 operating system with recent updates installed. Test case results showed the code to be working correctly before and after the production runs.

After the potential source terms are defined, the second step in the PFP complex emissions analysis is to compute the airborne and deposited concentrations using the AERMOD air dispersion model. This appendix documents the air dispersion modeling approach, assumptions, and input data.

C.1 Air Dispersion Modeling Approach

The various phases of the demolition of the PFP facilities will generate fugitive dust emissions that are expected to have low levels of particulate transuranic content. The AERMOD air dispersion model is used to assess air quality resulting from complex onsite fugitive dust emissions accounting for the combination of ambient transport and dispersion dust and building wake effects.

The air dispersion modeling approach is designed to provide output products that are useful in the PFP demolition planning process in terms of providing an understanding of the air and soil impact levels projected for a given demolition option. An approach is needed that can address the potentially very large number of permutations and combinations of ambient weather conditions and the multi-faceted demolition options for each of the components of the PFP facilities.

The approach is to consider each major demolition component of the PFP facilities separately. These computations are used to build a cumulative picture of potential environmental contamination from the full demolition of the PFP facilities. The air exposure analysis is independent of the demolition start date. Because the deposition analysis is based on the summation of the impacts of a series of events, the deposition analysis requires an assumption of a postulated start date and definition of a period of time elapsed during the year for the demolition of each component.

In addition to emission rates from the source term analysis being highly dependent on the demolition options that are selected, the location and size of those emissions are also defined for each of the selected demolition options.

As the result of their different measures of exposure levels, different approaches are used for the air concentration exposures and soil deposition totals. The concern for air exposures is based on the potential levels of air concentration during the demolition of each component. The concern for soil exposures is based on the total deposition not exceeding a specified surface concentration.

C.2 Airborne Exposures

Airborne exposures (time-integrated air concentrations) are evaluated in terms of weekly total exposures. A total weekly exposure limit is defined as 12 DAC-hours/week. For the evaluation of potential air exposures, the duration of the demolition activities is important only in terms of what activities are expected to occur in a one-week time frame. Thus, assuming that the demolition of each component of the PFP complex does not overlap within the same week, the potential air exposures can be independently evaluated for each component.

The analysis determines the weekly air exposures downwind of the demolition activities accounting for the week-to-week variations in potential release rates and ambient meteorological conditions. The demolition activities involving the largest estimated release rates are evaluated first. These results define the largest potential air exposures. Calculations are performed to develop a distribution of potential concentrations; these are sorted to obtain the value that is not exceeded more than 5% of the time (the 95^{th} percentile). The results for the air dispersion modeling are presented as maps of maximum potential weekly air exposures (at the 95^{th} percentile level) computed over some meteorological time span (annual, seasonal, etc.). The results for the air modeling are presented in terms of 95^{th} percentile potential weekly air exposures at selected environmental locations.

C.3 Deposition Exposures

Deposition exposures (cumulative depositions) are evaluated in terms of total accumulations on ground level surfaces downwind of the demolition activities. A total alpha deposition concentration limit of 20 dpm/100 cm^2 is used. For the evaluation of potential deposition exposures, the duration of the demolition activities is important. That is, the deposition patterns from the sequential demolition of each of the various components of the PFP facilities must be cumulatively added to evaluate the potential total deposition exposure.

The analysis of each component structure determines the total potential deposition exposures resulting from the demolition of that component alone. The demolition activities involving each of the components are evaluated. To allow logical sequencing of the deposition results, the demolition of each component is assumed to occur over some specific period of elapsed time that represents the “window” during a year that demolition is assumed to occur. The order of deposition analyses follows the air exposures analyses. Assuming the deposition results for each component are less than the air exposure limit, then the potential total deposition exposures from all components are computed.

For each facility or facility component, the soil deposition results are presented as maps of potential total deposition amounts from all of the demolition activities.

The patterns of total deposition for a demolition activity are computed for the demolition period using the average emission rate for that demolition activity. These deposition patterns are evaluated for some appropriate period of meteorological data. The results for the air dispersion modeling are presented as maps of total maximum potential deposition exposures computed for activities during the component’s period of elapsed time.

C.4 AERMOD Modeling Assumptions and Input Data

The modeling of potential exposures accounting for building wake effects with AERMOD requires the use of point source releases. Area sources such as walls and ceilings are approximated by a grid of point sources. The use of points to approximate an area is useful in that it does allow, if needed, the analysis to account for concentration variations over those areas.

Source Characteristics: The main sources for air emissions will be the building structure demolition and waste loading activities. These sources were modeled as a matrix of point sources. The AERMOD runs were configured to directly produce maximum hourly concentration and deposition values for the days associated with the demolition activities.

Meteorological Data: The air dispersion analysis used multiple years of local meteorological data to define the local dispersion climatology. Six recent years of meteorological data records (calendar years 2004 to 2009) were obtained from the Hanford Meteorological Station (HMS) database for the analysis.[1] This period was used to provide comparability to earlier versions of this report. Surface meteorological input data to AERMOD consisted of a merged dataset containing surface data incorporating wind speed and direction data from the Hanford telemetry station number 19 located in the 200W area combined with meteorological surface observations from the central HMS station. Vertical structure input data to AERMOD consisted of radiosonde data from the meteorological station at the Spokane airport.[2]

Figure C.1 shows a wind rose plot[3] based on all conditions for this six years of record. Reflecting the modeling assumption that all demolition activities occur either during the day shift (6am to 4pm) or during swing shift (4pm to 2am), Figures C.2 and C.3 show a summary of the wind conditions for those two time periods, respectively. Figures C.4 and C.5 show how the wind conditions vary as function of the time of year for the morning and afternoon shifts.

The year 2009 is used to demonstrate inter-annual variability. Figures C.5 to C.10 correspond to the 1-year average values shown in Figures C.1 to C.5. Comparison of these figures shows the major features are essentially the same between the six- and one-year plots.

[1] Ken Burk, Hanford Meteorological Station, Email dated 12/13/2007 defining link for Hanford meteorological data.
[2] Forecast Systems Laboratory (FSL)/National Climatic Data Center (NCDC) Radiosonde Database Access, http://raob.fsl.noaa.gov/ for radiosonde data for Spokane, Washington.
[3] Meteorological convention is used, which defines winds by direction from which they come.

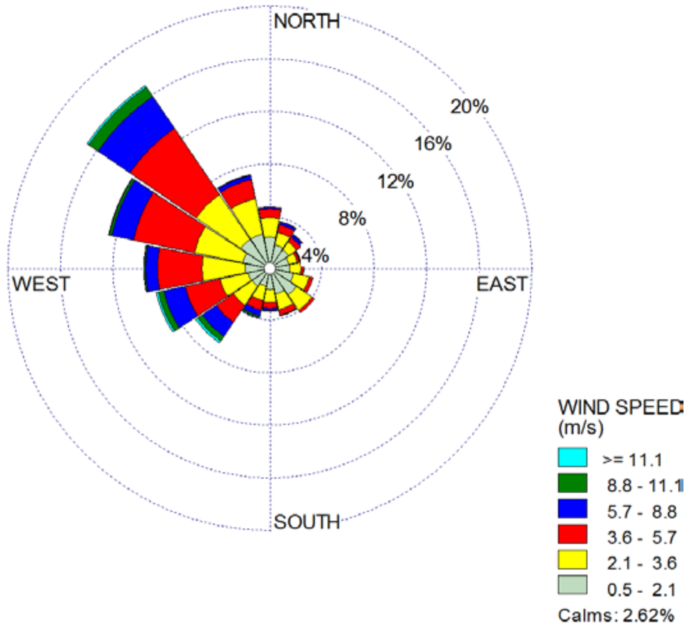


Figure C.1. Average Six Year (2004–2009) Wind Rose – All Conditions

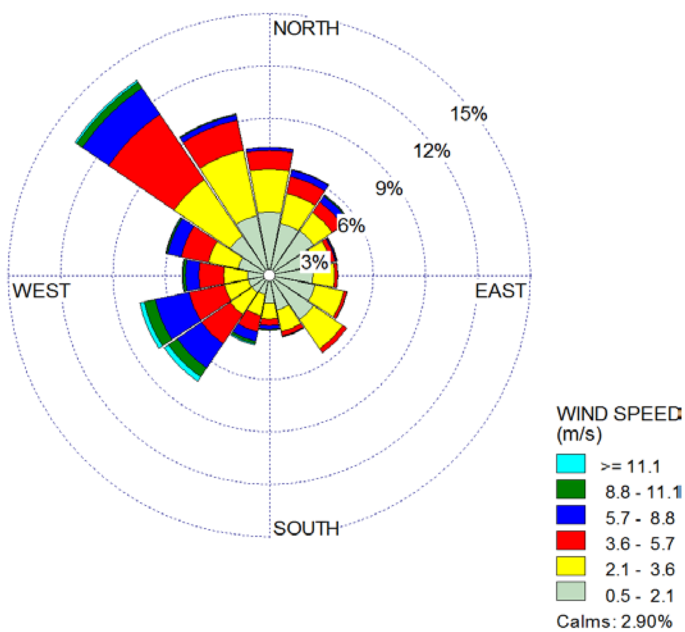


Figure C.2. Average Six Year (2004–2009) Wind Rose – Day Shift Conditions

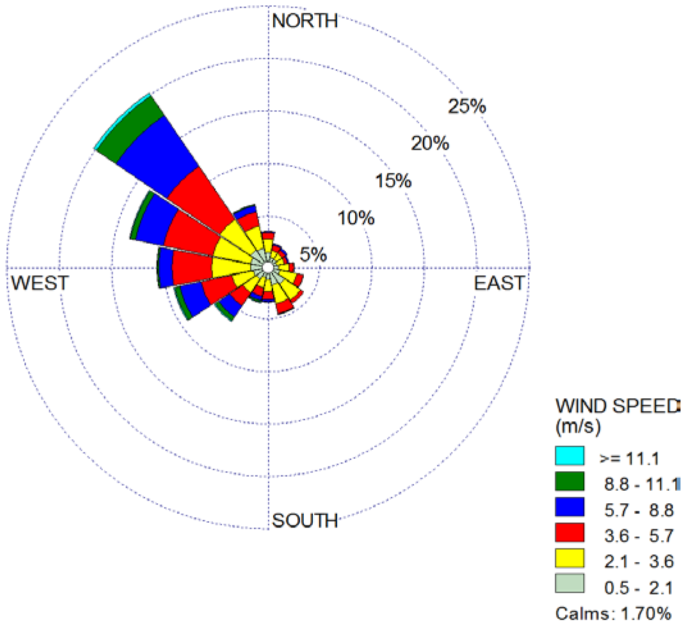
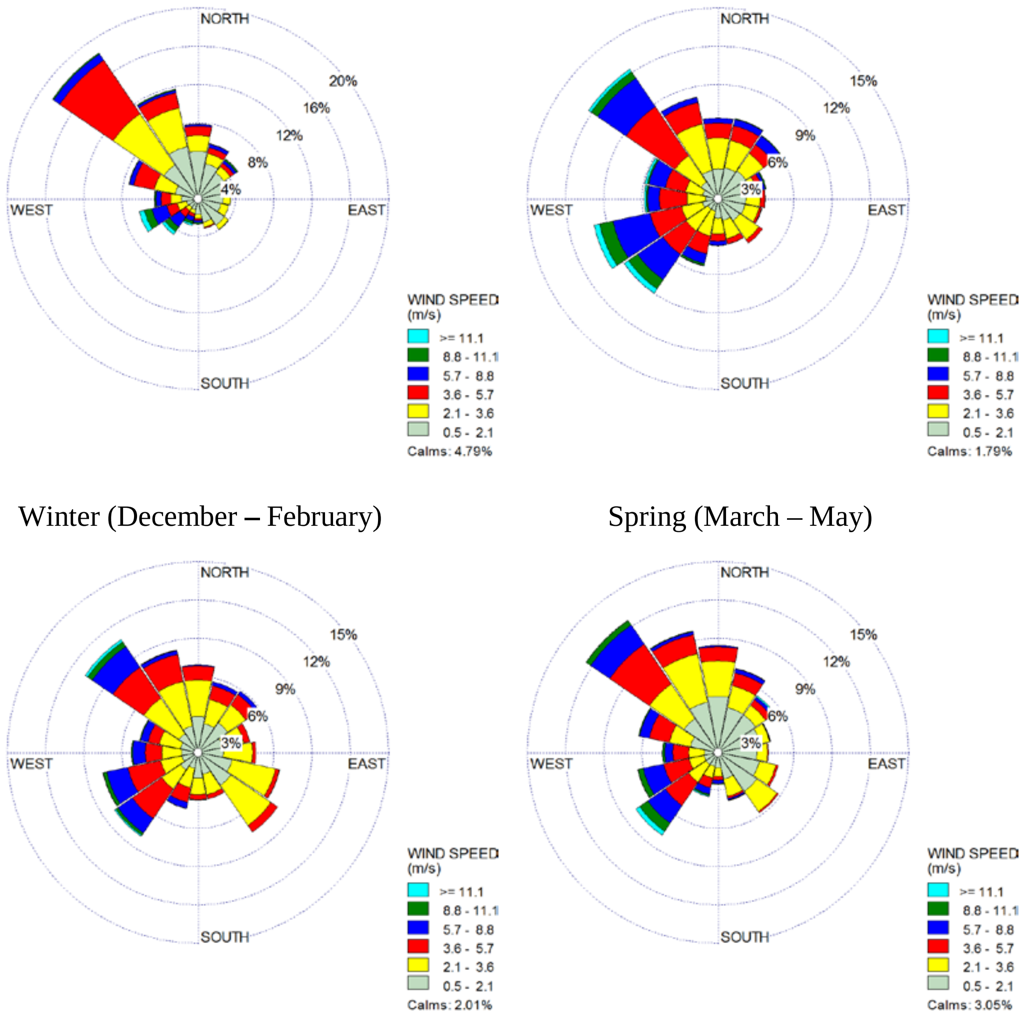


Figure C.3. Average Six Year (2004–2009) Wind Rose – Swing Shift Conditions



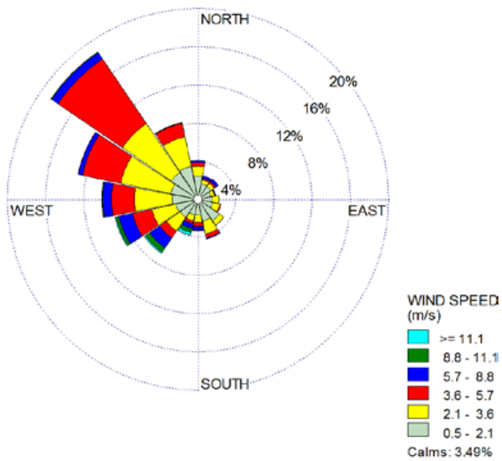
Winter (December – February)

Spring (March – May)

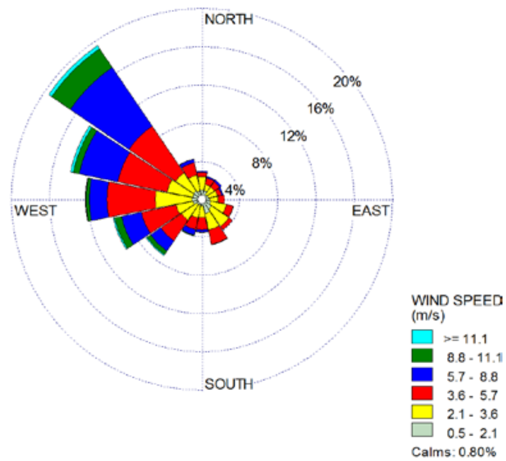
Summer (June – August)

Fall (September – November)

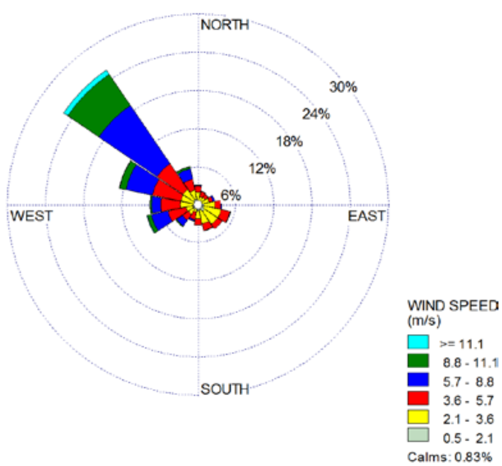
Figure C.4. Seasonal Average Six Year (2004–2009) Wind Rose – Day Shift Conditions



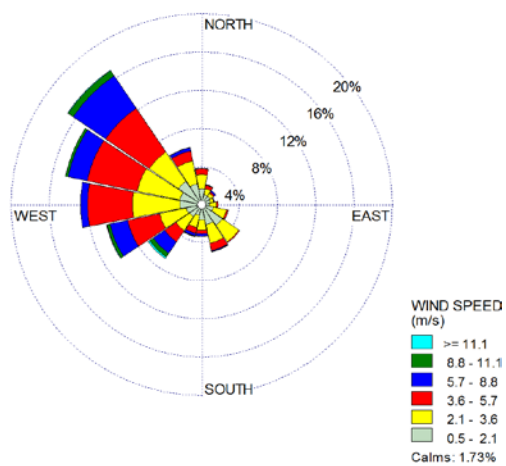
Winter (December – February)



Spring (March – May)



Summer (June – August)



Fall (September – November)

Figure C.5. Seasonal Average Six Year (2004–2009) Wind Rose – Swing Shift Conditions

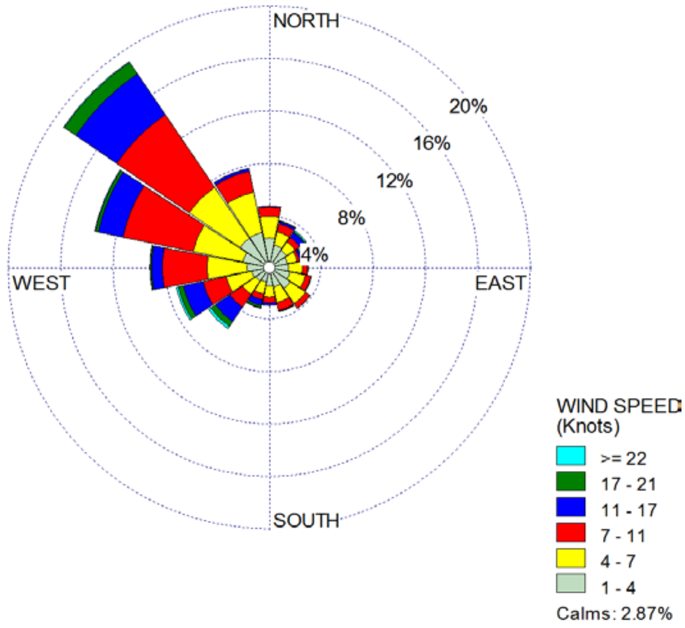


Figure C.6. Annual (2009) Wind Rose – All Conditions

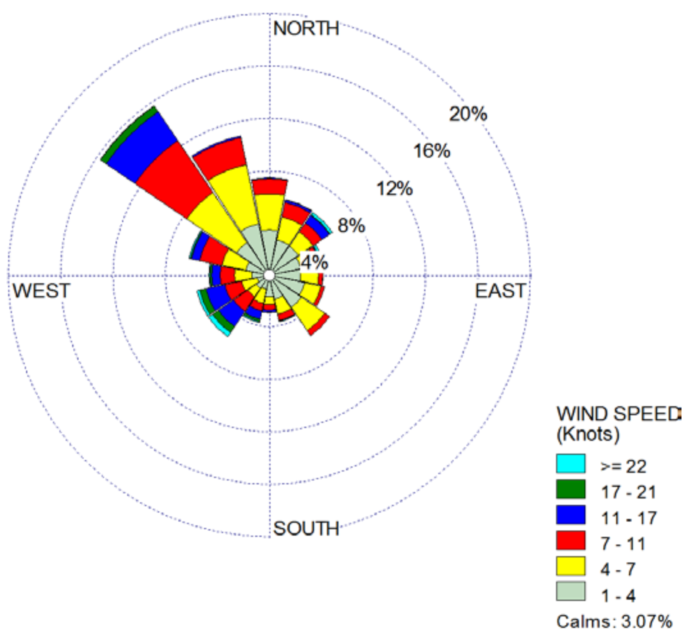


Figure C.7. Annual (2009) Wind Rose – Day Shift Conditions

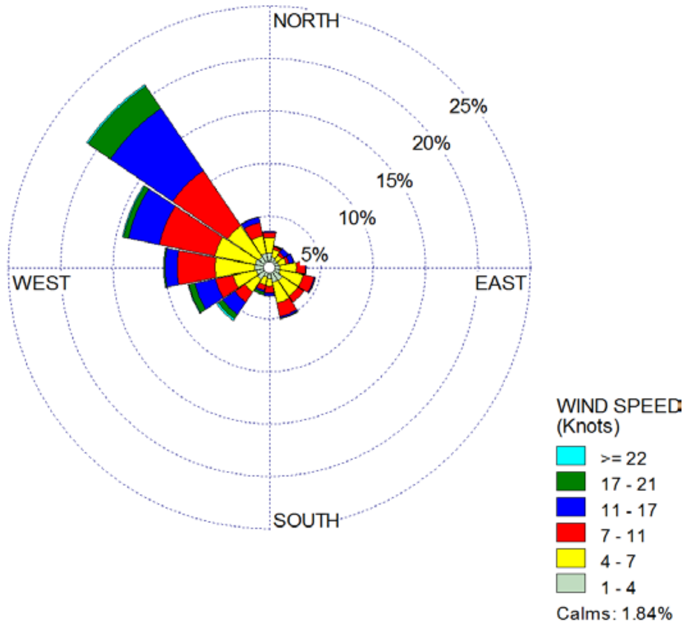
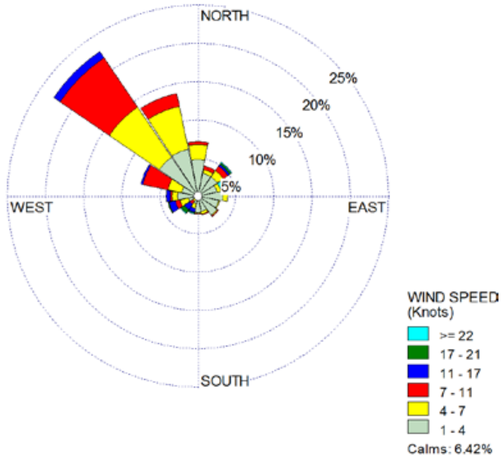
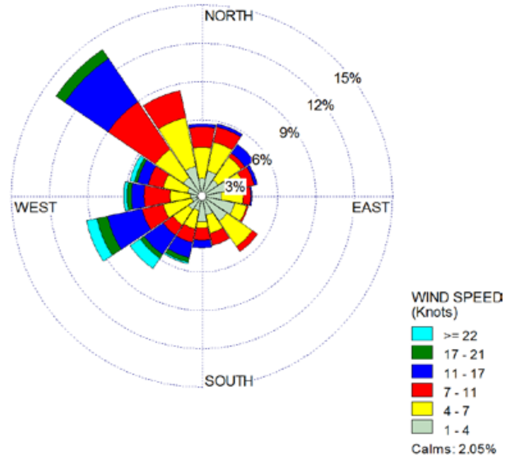


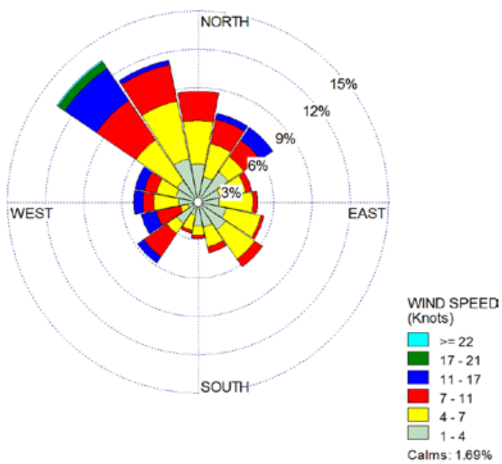
Figure C.8. Annual (2009) Wind Rose – Swing Shift Conditions



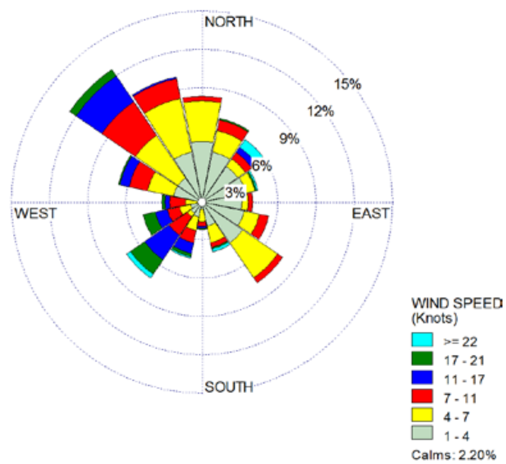
Winter (December – February)



Spring (March – May)

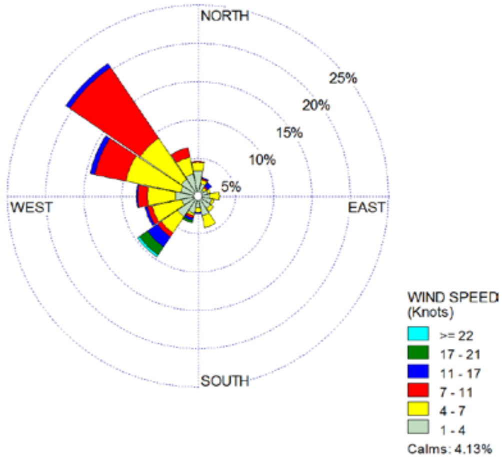


Summer (June – August)

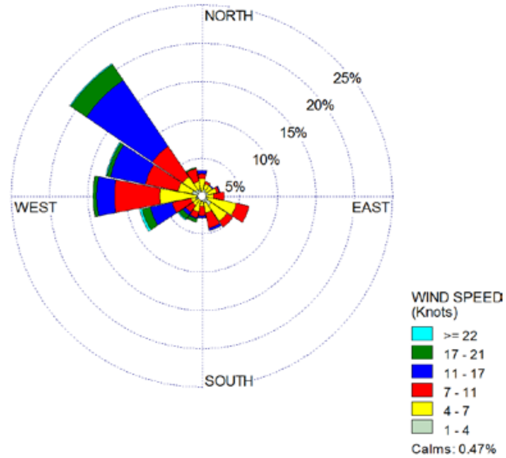


Fall (September – November)

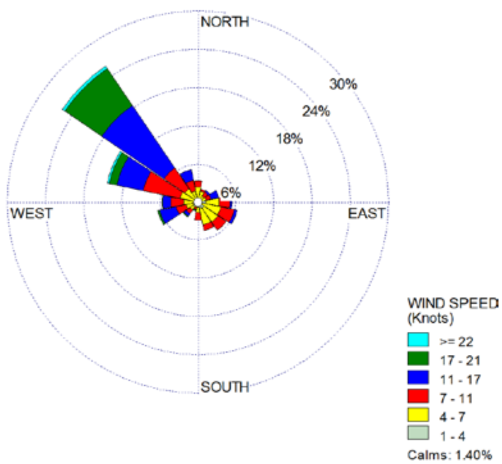
Figure C.9. Seasonal Annual (2009) Wind Rose – Day Shift Conditions



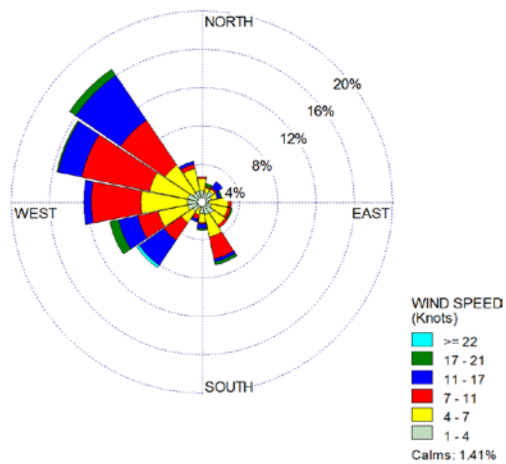
Winter (December – February)



Spring (March – May)



Summer (June – August)



Fall (September – November)

Figure C.10. Seasonal Annual (2009) Wind Rose – Swing Shift Conditions

Modeling Approach: The demolition activities are to occur during the day and swing shifts. The worst-case scenario resulting in the highest air concentrations is for the majority of the release to occur over a short time period. To evaluate the potential exposure levels from the planned demolition activities, the local patterns of potential peak air concentrations and soil deposition were computed as though the estimated release from each of the buildings occurred during one hour. By looking at the potential peaks for all the hours during the planned work periods, the worst case values are defined. The two proposed 3-month time periods for the demolition activities are included in this annual bounding computation.

Receptor Grids: Computations were made for a rectangular receptor grid appropriate for defining the spatial patterns of the locations of the maximum air concentrations and deposition amounts.

C.5 References

EPA – U.S. Environmental Protection Agency. 2008. Technology Transfer Network Support Center for Regulatory Air Models, http://www.epa.gov/scram001/(Access last checked 6/5/2008).

Project Hanford Management System. 2002. *Computer Software Management*. HNF-PRO-309. October 24, 2002. Fluor Hanford, Inc. Richland, Washington

Appendix D

Quality Control Procedures

Appendix D – Quality Control Procedures

D.1 Overview

QA requirements specified by PNNL were followed. A QA review of computations and results was conducted. Special aspects of QA requirements for this project are:

1. All modeling computations will be performed with commercial software: either by EXCEL or by AERMOD codes.
2. The equations for all computations in EXCEL will be documented in the project report.
3. The AERMOD model will be tested with the AERMOD distribution test cases to assure the AERMOD model is operating as expected. Documentation of run time options will be documented in the project report.
4. The versions of EXCEL and AERMOD, the computer platforms, and the computer operating system versions will be documented in the final report.
5. Electronic copies of all EXCEL spreadsheets and AERMOD run files used in the project results will be stored in the project file.

Descriptions of the details of this approach relative to conducting simulations with AERMOD are given below.

D.2 AERMOD Simulations Validation and Verification Approach

The following guidance documents the approach used by PNNL for validating and verifying model runs made in the EPA's AERMOD dispersion model. In short, the guidance ensures that the appropriate model version is being used, the modeling system is functioning as expected, and the model inputs are reasonable and correct for the scenario. A checklist has been developed to aid the modeler in validating and verifying model inputs; the checklist can be completed and submitted along with the model report to document validation and verification procedures used in performing the AERMOD model run.

1. Determine which model is appropriate for the current modeling application:
   a. The AERMOD modeling system is the preferred/recommended dispersion model to be used in almost all circumstances, including State Implementation Plans (SIP) revisions for existing sources and New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs.
   b. Alternative models (e.g., ISC) can be used in regulatory applications, but require case-by-case justification from the reviewing authority.
2. Verify the latest regulatory version of the modeling system is being used:
   a. The EPA releases new versions of the AERMOD modeling system to correct known issues or to implement new features in the model. Verify the correct regulatory version of AERMOD modeling system is being used by contacting the software distributor (e.g., www.breeze-software.com, www.lakes-envirionmental.com) or by reviewing the model change bulletins available on the EPA's website: http://www.epa.gov/scram001/dispersion_prefrec.htm.

b. If necessary, download and install the regulatory version of the AERMOD modeling system from the vendor or the EPA.

3. Validate the modeling system is working properly:

   a. The AERMOD modeling system should be validated to ensure it is working properly prior to using it for the intended application. Test cases are installed by the model vendor (e.g., www.breeze-software.com, www.lakes-envirionmental.com) and should be run to make sure the model output agrees with the original output. File comparison software, such as "Beyond Compare" available from PNNL's Managed Software, make comparison of the model output files a simple process.

      i. If the file output differs, further investigation will be required to determine the source (e.g., model version) of the difference and determine if the results are acceptable.

   b. The EPA provides model test cases on their website, http://www.epa.gov/scram001/dispersion_prefrec.htm, which can also be used to validate the modeling system is running properly.

4. Enter all model inputs applicable to the modeling scenario. If using vendor software (e.g., BREEZE, Lakes Environmental), model input entry will be performed through a Windows interface (preferred). If using the EPA's DOS version, model entry will be performed via a formatted text input file. AERMOD input is echoed to the primary output file; these inputs should be verified and validated to ensure entered values are correct. A checklist was used as guidance to verify and validate model inputs. Key issues to consider when creating model scenarios include:

   a. Terrain - if terrain is to be considered, source and receptor locations should be entered using the proper Universal Traverse Mercator (UTM) coordinates. The latest regulatory version of AERMAP should be used, along with the appropriate digital elevation model (DEM) files, to determine terrain heights for model objects.

   b. Building Downwash – point sources (e.g., stacks) on or near buildings may be subject to building downwash. Include all downwash structures in the modeling analysis, including structures not located on the facility's property if applicable. Downwash structures outside of 5L may be excluded from the analysis (note: "L" is defined as the lesser of the height or maximum projected width for a particular tier or structure). All non-downwash structures should be excluded from the modeling analysis. Non-downwash structures include lattice-type structures such as switchyards, water towers, and elevated storage tanks. Perform a building downwash analysis using the latest version of the Building Profile Input Program (BPIP-PRIME). Downwash calculations should not be performed until all point sources and buildings have been entered into AERMOD *and* terrain has been imported; this ensures that all model objects have the correct relative heights.

   c. Receptors – receptor spacing of sufficient coverage and density should be chosen to ensure sufficient density to determine worst-case predicted ground level concentrations in off-property areas. Predicted concentrations should decrease near the edges of the receptor grid(s).

   d. Meteorology – meteorological data should be processed by a qualified meteorologist using the latest regulatory version of AERMET. Selection criteria for the choice of the meteorological station(s) and surface characteristics should be documented by the analyst processing the meteorological data in AERMET. In general, the latest years of meteorological data should be used in the dispersion modeling analysis. However, the modeler should seek approval from the regulator prior to using the meteorological dataset in a specific application.

5. Verify the echoed model inputs in the AERMOD output file: After completing a model run, the model inputs—which are echoed to the primary AERMOD model output file—should be reviewed to verify values have been entered correctly. Model output should be reviewed to determine if output concentration and/or deposition values are reasonable.
6. Verify the AERMOD modeling system continues to perform as expected: To ensure the AERMOD modeling system performed as intended, the modeler can re-run the model test cases and verify test-case model outputs continue to agree (see Step 3a, above).

A checklist is used to verify and validate AERMOD model runs being used to support compliance-related work. The checklist can be completed by the modeler and affixed to the model report as supporting documentation on model verification and validation. Use of this checklist will ensure a consistent modeling approach has been followed. In addition, the checklist will help to identify and avoid common modeling errors such as:

- Emission rates or stack parameters that are unacceptable and require revision.
- Modeled emission rates or parameters that do not match the permit application.
- Buildings/property boundary/emission unit locations that do not match the plot plan.
- Inconsistent base elevations for buildings and stacks.
- Incorrect source inputs and dimensions.
- Sources with horizontal or obstructed exhaust modeled with an incorrect exit velocity.
- Terrain elevations missing or incorrect.
- Receptor grid extent is insufficient.
- Meteorological data are not appropriate.
- Use of the incorrect model or model version.

Appendix E

Input Data for PFP Building Simulations

(Included on CD only)

Appendix F

AERMOD Output File Listing

(Included on CD only)

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