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REMOVAL SITE EVALUATION SAFE SHUTDOWN PROGRAM OCTOBER 1992

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REMOVAL SITE EVALUATION

SAFE SHUTDOWN PROGRAM

OCTOBER, 1992

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

DOE FIELD OFFICE - FERNALD

DEPARTMENT OF ENERGY
CINCINNATI, OHIO

SAFE SHUTDOWN PROGRAM

REMOVAL SITE EVALUATION

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 SOURCE TERM 1

3.0 EVALUATION OF POTENTIAL THREAT[1] 3

4.0 ASSESSMENT FOR THE NEED FOR REMOVAL ACTION 16

5.0 APPROPRIATENESS OF A RESPONSE 17

[1] Data extracted from the NEPA Environmental Assessment prepared for the Safe Shutdown Program.

1.0 INTRODUCTION

For over thirty-five years, the Feed Materials Production Center (FMPC), now referred to as the FEMP, produced uranium products for the Federal Government. Site construction began in 1951 and production operations started in 1953 under the Atomic Energy Commission (AEC). The FEMP contains nine production plants, along with numerous support buildings, in which intermediate or finished products in the manufacturing of uranium fuel elements were produced.

Although the immediate cessation of production-related operations occurred in July 1989, much of the equipment was scheduled for restart in order to prepare for continued production and to produce intermediate products for future DOE use in programs at other sites. The official termination of the FEMP production mission took place in June 1991, without the restart of the production processes or the stabilization of intermediate products.

2.0 SOURCE TERM

The following paragraphs summarize the activities that occurred when the plants were operational and the current inventories of stored materials in each of the FEMP Production Plants. Containers include boxes, cans, drums, J-Hoppers, T-Hoppers, and skids. Additional materials that are present as hold-up in pipes and process equipment, will be removed during the Safe Shutdown Program. Estimated hold-up materials are listed in Attachment I.

Plant 1 - activities included the operation of a sampling line for incoming uranium materials, a roller mill to reduce the particle size of MgF_2, a safe geometry digester, a drum reconditioning system, a scrap drum baler, dust collectors, and maintenance of warehouses and storage pads for drummed residues and wastes.

Inventories for Plant 1 include: 25,869 containers of depleted uranium product and residues, of which 22,580 are low-grade process residues; 14,823 containers of enriched uranium residues, product and scrap material, of which 13,498 are low-grade residues; 1,852 containers of normal uranium residues, scrap, and product, of which 827 are low-grade residues; and 13,683 containers of thorium consisting mainly of ThF_4, ThO_2, and thorium metal.

Plants 2/3 - activities included the operation of a nitric acid digestion system, a metal dissolver system, a liquid-liquid extraction system, a boildown and denitration system where purified uranyl nitrate (UNH) is converted to orange oxide (UO_3), a nitric acid recovery system, the combined raffinate and hot raffinate system, a refinery sump system, and dust collectors.

Plants 2/3 currently contain four drums of low-grade, enriched uranium residues.

Plant 4 - activities included the operation of reactors to convert orange oxide (UO_3) to brown oxide (UO_2) or black oxide (U_3O_8) and then to green salt (UF_4), ammonia dissociators, nitrogen generators, an HF recovery area, a tank farm, product packaging stations, and dust collectors.

The Plant 4 inventories include the following stored materials: 12,933 containers of depleted uranium residues and product (12,283 are cans of UF_4); 5,355 cans of enriched uranium residues and product (4,659 are cans of UF_4); and two drums of low-grade normal uranium residues.

Plant 5 - activities included derby production that featured jolters, F-machines, Rockwell furnaces, breakout system, slag milling and liner preparation. Other operations included ingot manufacturing that featured vacuum remelt casting furnaces, crucible charge and burnout areas, ingot separation, mold cleaning and painting, ingot sawing and saw blade sharpening, a Hilco oil reclaiming system, and dust collectors.

The inventories of stored materials in Plant 5 include the following: 1,917 containers of depleted uranium residues, product and scrap metal; and 2,315 drums of enriched uranium residues, product and scrap metal.

Plant 6 - activities included machining processes to heat treat ingots before shipping for extrusion, cropping extruded ingots, heat treating blank cores, machining cores to a finished target element, cleaning and briquetting chips, machining pillow shaped ingots for sizing and scalping. Other activities included operation of a rolling mill system, a waste water processing system, and electrostatic precipitators.

The inventory of stored materials in Plant 6 includes the following: 7,844 containers of depleted uranium residues, product and scrap metal; 14,992 containers of enriched uranium residues, product and scrap metal; and 98 containers of normal uranium residues, product and scrap metal.

Plant 7 - was operated during the 1950's to reduce UF_6 to UF_4. However, all process equipment was removed in the late 50's and the building has been used mainly for storage of empty cans and drums. Cans of UF_4 from the Pilot Plant and Plant 4 are presently stored in Plant 7. The number of containers stored in Plant 7 are included in the inventories reported for Plant 4 and the Pilot Plant.

Plant 8 - activities included the operation of several types of furnaces, liquid filtering systems, a halide acid metal dissolution area, a drum washer, a ball mill, and dust collectors.

The inventory of stored material in Plant 8 includes the following: 2,193 containers of depleted uranium residues; (2,179 drums of low-grade and 14 drums of high-grade); 3,467 containers of enriched uranium residues (3,463 drums of low-grade and four drums of high-grade); and one drum of normal uranium high-grade residues.

Plant 9 - activities included ingot casting in N-Reactor vacuum remelt casting furnaces, derby soaking in Rockwell furnaces, ingot sawing and machining, Zirnlo scrap decladding, and the operation of a waste water processing system, electrostatic precipitator, and dust collectors.

The current inventory of stored material in Plant 9 includes the following: 169 containers of depleted uranium residues and product; and 4,322 drums of enriched uranium low-grade (3,943 drums) and high-grade residues (299 drums) and scrap metal (58 drums).

Pilot Plant - activities included small-scale facilities of all the production processes for the FEMP. In early 1980's a production scale UF_6

to UF_4 unit was installed and operated. In the late 1980's, a new UF_6 to UF_4 unit was installed in a newly constructed building; however, it was never operated.

The Pilot Plant inventory currently consists of the following stored materials: 2,776 containers of depleted uranium residues and product (2,459 of which are cans of UF_4); 284 containers of high- and low-grade uranium residues; and 2,391 containers of normal uranium (2,388 of which are cans of UF_4 product and the remaining three drums are scrap metal).

3.0 EVALUATION OF POTENTIAL THREAT

The purpose of this assessment is to estimate the reasonable maximum doses and risks for individuals directly involved in Safe Shutdown activities and individuals not specifically involved in the Safe Shutdown program. Furthermore, in order to estimate these doses and risks three hypothetical exposure scenarios were developed. These exposure scenarios are: 1) on-site workers (associated with Safe Shutdown), 2) on-site workers (not associated with Safe Shutdown), and 3) off-site residents (public). The exposure scenarios used in this evaluation represent the basis of the characterization for doses and risks for the facility with the greatest source term. These scenarios represent the credible release resulting from proposed activities under safe shutdown. The facility selected for the exposure assessment was Plant 2/3. This facility was selected based on the types of materials, potential contaminants, processes, and total estimated inventory anticipated both inside and outside of the structure. The total expected inventory has been estimated to be 174 Ci (curies) of uranium. This uranium is available in a variety of forms including uranyl nitrate. Additional details are provided in the section on source characterization. The specific details for each of these exposure scenarios are outlined below:

(1) A worker who engages in activities both in the facility and in the vicinity of the Plant 2/3. This worker will be involved with the actual safe shutdown activities. The time frame for this scenario is expected to be eight hours per day and 5 days per week for one month.

(2) An on-site worker not directly involved in the specific removal action. This individual is assumed to work in the vicinity (100 meters) of the contaminated area on a daily basis, five days per week, for a total length of time of one month.

(3) The last exposure scenario considered involves the potential for exposure to members of the general public where the exposure will continue for the entire year as a result of atmospheric dispersion. The release and transport is divided into two main facets: A) the actual release of material which is a short time frame of approximately one hour and B) the continued resuspension of contaminated dust which will occur over the entire year.

Figure 1 illustrates the location of Plant 2/3 within the Production area (Operable Unit 3). Table 1 illustrates the available data corresponding to the source term within the facility.

The format for this investigation will consist of the following components: 1) source characterization, 2) exposure scenarios and their associated parameters, 3) exposure pathways and their methodology, and 4) dose and risk results for each exposure scenario.

SOURCE CHARACTERIZATION

The source term is assumed to be the material contained in the Plant 2/3 facility that has been estimated to be present from previous operations. For purposes of this investigation, the source term is assumed to be uniformly and homogeneously distributed in the area around the critical features of the Plant 2/3 facility. These assumptions are made for two reasons: 1) to ensure that a conservative exposure or dose and risk estimate is made and 2) to account for the lack of measured or observed concentrations of contaminants that may be released outside the Plant 2/3 facility.

Plants with greatest or most significant source term determined by evaluation of the 'holdup inventory' are: Plant 2/3, with 174 Ci of uranium (234, 235, and 238), and Plant 6, with 18 Ci of uranium (234, 235, and 238). The estimate of doses and risks will be based on the source term associated with Plant 2/3. Additional radionuclides and chemicals have been identified through ongoing investigations or process knowledge as potential contaminants of concern. These other radionuclides and chemicals are only considered qualitatively in the risk evaluation due to the small quantities (in comparison to uranium) present. The magnitude of the source term for the additional constituents is estimated by using a ratio of 1/1000 to the mass of uranium. Since there are fewer than 10 additional contaminants this would result in a total additional inventory for the other radionuclides and chemicals to be less than 1% of that of uranium. It should be noted that other radionuclides present during process operations constituted impurities in the system and active measures were taken to separate these out of the product streams. A table is provided listing the various slope factors and conversion factors for the inhalation and direct exposure pathways.

The total quantity of uranium present in Plant 2/3 is estimated at 174 Ci for uranium-238 and 188 Ci for uranium-234. These quantities are divided into several categories: 1) drummed material (4.15 mCi and 9.49 mCi for 238 and 234 respectively), 2) holding inventory (0.464 Ci and 0.717 Ci for 238 and 234 respectively), and 3) holdup inventory (174 Ci and 187 Ci for 238 and 234 respectively). This represents a total mass of approximately 5.24×10^8 grams (524 metric tons). As indicated by the relative activities for U-234 and U-238 these isotopes are essentially in secular equilibrium. Additionally the primary constituent of the total inventory is the holdup material, which is the focus of the safe shutdown removal activities.

The next component of the source term is the estimation of the area over which the uranium will be distributed. This volume of material is distributed throughout the Plant 2/3 facility in equipment, tanks, lines, and sumps. The difficulty associated with a quantitative dose and risk evaluation is to determine the maximum credible quantity of material which may be inadvertently released during the anticipated activities associated with the Safe Shutdown Removal Action. To accomplish this task a detailed evaluation of the facility was initiated to determine what process activities had taken place and the types of equipment used.

This evaluation provided the basis for assuming that the largest single source of material encountered during the various activities would be that associated with gaining entry to the equipment. Among the process equipment in Plant 2/3 the greatest exposure would most likely occur as a result of a release of uranyl nitrate (UNH) from piping or tanks in the digestion area or outside the facility.

In one of the typical 5000 gallon tanks it is expected that about 100 to 200 gallons of residual uranyl nitrate (UNH) will be remaining (usually as a result of drainage from process piping). This corresponds roughly to approximately 500 liters. The uranium concentration in the uranyl nitrate is approximately 200 grams uranium per liter (gU/L). This type of equipment, with an assumed quantity of 500 liters of uranyl nitrate, would contain approximately 100,000 grams (100 kilograms) of uranium. Therefore, exposure scenarios based on the release of 100 kilograms of uranium constitutes the maximum credible source term for evaluating the associated release and transport pathways.

RELEASE AND TRANSPORT PROCESSES

Release potential is dependent on the specific activities in which workers are engaged. These are listed below and are used here to describe the release potential.

FIELD ACTIVITIES:

The activities listed below are those activities which provide individuals with the potential for exposure. In each of the activities listed a worker involved with the Safe Shutdown Removal Action is in close proximity to bulk contamination so as to result in some level of exposure. The objective of this section is to define those scenarios or situations which can lead to significant release and transport of contaminants. A reasonable scenario describing a potential release and transport route is presented for each activity.

1. Remove excess material to an approved storage location. Since this activity involves packaging and handling of holdup material there exists the potential for an unplanned event. Unplanned events may include various containers being dropped, crushed, or otherwise breached and thereby permitting bulk excess material to be disbursed (this event may occur while attempting to place material in a container or during transportation of the container).

2. Isolate utilities for process equipment. During the isolation of specific equipment contact with both fixed and loose material may occur. Gases, liquids and solids may be present in such a manner so as to be released when adjustments are made to equipment.

3. Gain entry to contaminated process equipment. This activity can lead to contact with contaminants. Some equipment may require cutting tools to gain access thereby increasing the possible release and transport routes. Trapped gases could ignite and enhance the disbursal of contaminated material.

4. Transfer holdup material to storage containers. This activity is similar in nature to that described in #1 above. This activity concentrates on the actual placement of bulk contaminants into the

specific storage containers. Bulk material can be encountered in a variety of physical forms, thereby requiring the consideration of various release and transport possibilities. Liquids, gases, and fine particulates pose the most significant release modes. Gases and fine particulates (dust) pose the greatest transport potential.

5. Transfer filled storage containers to an approved storage location. This activity is similar to #1 above in that it involves the transportation of contaminated material. Containers of bulk material breached as a result of handling activities pose the most significant release modes for this activity. Once the container is breached the release and tranpsort scenarios are similar in nature to those described in #1 and #4 above.

On-site (workers not engaged in Safe Shutdown activities) doses and risks are developed using the simplified box model to represent atmospheric transport. The off-site doses and risks are developed using the results of the box model on-site as a source term and then applying dilution factors that were determined using the Gaussian plume equation. These dilution factors are based on a single sector and a single wind speed/stability class designation. The direction selected is that which has the greatest potential for exposing members of the general public. The off-site consequences of a release are only considered for those activities which occur outside of a facility or involve sufficient energy to escape the facility after release. Breached containers of material, which will not explode or ignite when in contact with the environment, are not considered to have sufficient energy to escape a building. These same drums outside of a facility are considered in the evaluation of release and transport evaluation.

In general, contaminant release and transport will be addressed specifically for each scenario considered. Release involves the quantity of each contaminant that is available for transport within facility or the environment outside. Transport then is related to the disbursal of material, through natural mechanisms, in an uncontrolled fashion. The transport processes considered in this assessment are limited to those which result in the maximum credible concentrations at the specified receptor locations. The principal transport process (route) considered is atmospheric dispersion. The transport processes considered include both volatization of the source material and resuspension of contaminated dust.

For the purpose of this assessment the uranyl nitrate (discussed in the source term development section) is assumed to be available for both volatilization and resuspension. This approach, although conservative, does account for other materials that may indeed be dispersible. The fraction of contaminated material that is actually transported by the wind is based on that quantity of material which can become airborne. This value is estimated and is called the Airborne Respirable Fraction (ARF). The ARF used for this evaluation was that identified for liquid releases and corresponds to 10% of the total quantity released.

Transport processes specifically excluded are vadose zone and groundwater migration, surface water, soil erosion and runoff, and accumulation of contaminants on plant material. These processes were excluded due to the long transport times relative to the release events. Removal actions would be implemented immediately in the event that material was released to the environment and posed a long term transport potential of this nature. The

exposure scenarios discussed in the next section are based on short term immediate and acute exposures.

EXPOSURE SCENARIO AND PARAMETERS

The external radiation pathway is primarily controlled by gamma-ray radiation. Gamma radiation is the principal radiation of concern for the external radiation pathway because it is sufficiently penetrating to represent a dose at considerable distances. The Dose Conversion Factors (DCFs) for ground contamination are based on exposure at a distance of one meter above the ground. These DCFs represent the annual effective dose equivalent from exposure to external radiation.

The radiation dose from inhalation has been extensively evaluated by the International Radiation Protection Association in its Publication 30 (ICRP, 1979-1982). Dose equivalents in organs and tissues of the body are calculated with models that describe first the entrance of materials into the body and then the deposition and later retention of the radionuclides in the bodily organs. Dose equivalents estimate the energy deposition of the radionuclides in the tissues of the body (ICRP, 1979-1982). Dose conversion factors for inhalation represent the committed effective dose equivalents per unit intake of a radionuclide.

The first exposure scenario is the exposure to a worker who engages in activities in the contaminated area 8 hours per day 5 days per week for one month. These activities include direct handling of contaminated material and any operations involved with gaining access to equipment, piping, and tanks. The individual is required to wear a respirator along with other protection equipment, for examples gloves, and should therefore not be exposed to contaminants through either the inhalation or ingestion pathways.

The second exposure scenario evaluates the worker who is not involved with the removal action project. These workers are typical of FEMP employees engaged in other activities at the site. These workers are considered for the purposes of this evaluation to be within 100 meters of the hypothetical accident occurring during the safe shutdown activities. These workers are exposed to both the direct radiation and inhalation pathways. The total exposure time is broken into three parts: 1) direct radiation for 8 hours per day, 1 day per week for a 1 month period, 2) exposure to a plume of contaminated dust for a 1 hour period, and 3) exposure to resuspended contaminated materials 8 hours per day, 1 day per week for 1 month.

The third exposure scenario addresses the potential exposure of an off-site individual located at the site boundary (assumed to be 500 meters away from the source). This scenario investigates the same three pathways as Scenario 2. The primary difference between the two scenarios is that Scenario 3 has a longer time frame for the resuspension pathway and the concentration of the contaminants at the receptor are smaller.

The following information represents the various factors and parameters that are utilized for each scenario. There are several source term parameters that function to characterize the dose to the RME individual of exposure scenario 1. These source term parameters are either a component of the external radiation pathway or the inhalation pathway.

FS = Shape Factor, 1.
(Based on a circular, infinite medium.)

FD = Depth Factor, 1.

Since these parameters take on the value of unity for all of the exposure scenarios they do not affect the results and therefore will not be addressed further in this report.

In addition the following parameters are utilized to determine the doses and risks for each exposure scenario:

1) Dose Conversion Factor (DCF)
2) Source Strength (ST) (both airborne and surface)
3) Exposure Factor (EF)
4) Area Factor (AF)
5) Dilution Factor (Df)
6) Airborne Respirable Fraction (ARF)
7) Resuspension Factor (RF) or Air to Soil Ratio (ASR = 2×10^{-4} g/m^3)
8) Inhalation Rate (IR) (assumed = 8400 m^3/yr)
9) Surface Soil Density (Rho-b) (assumed = 1.8 g/cc)

The first parameter considered is the dose conversion factor (DCF). The three contaminants considered in this study are uranium, thorium, and radium. The principal isotopes considered are thorium-230, radium-226, uranium-234, and uranium-238 are addressed in detail. The DCFs utilized are for these isotopes which include several short lived daughters. Table 1 presents the DCFs for each exposure pathway and isotope.

TABLE 1:DOSE CONVERSION FACTORS (DCFs)

ISOTOPE	INHALATION (mrem/pCi)	DIRECT EXPOSURE (mrem/yr / pCi/cm^2)
uranium-234	1.3×10^{-1}	8.07×10^{-4}
uranium-238	1.2×10^{-1}	2.46×10^{-2}
thorium-230	2.6×10^{-1}	9.07×10^{-4}
radium-226	7.9×10^{-3}	1.69

The next parameter addressed is the source strength (ST). The discussion of the quantity of uranium that may be released was presented in the section covering the source term. The information provided here is the final results of the analysis and represents those values used in the dose calculations. Table 2 presents the dilution factors and airborne respirable fractions. These values are then multiplied by the quantity of each contaminant released to arrive at the concentrations for each isotope. Table 3 provides the surface source strength for each distance considered in the inhalation pathway for resuspended particulates (this is based on an assumed deposition velocity of 1×10^{-4} m/sec).

TABLE 2:PARAMETERS ASSOCIATED WITH PLUME CONCENTRATION

Distance (meters)	Dilution Factor (Df)	Airborne Respirable Fraction (ARF)
10	0.5488	0.1
100	0.0175	0.1
500	0.0011	0.1

TABLE 3:RESUSPENSION FACTORS AND SURFACE CONCENTRATION

Distance	Df (S/m^3)	Surface Conc. (pCi/cm^2)	Area Factor
10	0.5488	6.34×10^3	0.43
100	0.0175	2.02×10^2	0.51
500	0.0011	1.21×10^1	0.68

Exposure Factor (EF) which describes the individual's total exposure time. The factor EF is defined as follows for each of the three exposure scenarios. The exposure factor EF is a measure of not only the time frame of the exposure but also includes the inhalation rate for the inhalation pathways. Table 4 presents the exposure factors for each scenario.

TABLE 4:EXPOSURE FACTORS (EF) FOR EACH EXPOSURE SCENARIO

SCENARIO	Distance (m)	Exposure Time (hrs)	Exposure Factor
#1	0	173	0.02
#2 Direct	100	34.6	3.9×10^{-3}
#2 Inhalation plume	100	1.0	0.96
#2 Inhalation resuspension	100	34.6	33.2
#3 Direct	500	416	0.047
#3 Inhalation plume	500	1.0	0.96
#3 Inhalation resuspension	500	416	399

The area factor which was already provided in Table 3 is needed to account for the total area available for resuspension. For this reason the area factor AF increases as the distance from the release increases. The AF approaches unity asymptotically as the distance from the source increases. The parameters identified above for use in the exposure assessment relate to both the direct and inhalation pathways. Some of the additional parameters which cover the inhalation pathway via resuspended dust are as follows:

$FA_2 = A^{1/2}/(A^{1/2}+DL)$.

Bulk Density = soil default value of 1.8 g/cm^3 (this is used for both in- and out-side of buildings.

A = Area of Contamination. DL = Dilution length, default value of 3 meters is typically used (out side of the building).

FI_2 = Inhalation Rate, 8400 m^3/yr.

Similarly the airborne respirable fraction and the dilution factor have been provided to assist in the development of the source term. The dilution factor Df determined through the application of the Gaussian Plume equation to a hypothetical release. The Df is determined on a unit source strength basis and it is assumed that the relationship between the source strength and the concentration in the plume is linear with the Df. The airborne respirable fraction ARF is that quantity of material release that actually becomes airborne and is available for transport. The scenarios considered in this study involved liquid releases and therefore an ARF equal to 0.1 (or 10% of the total quantity released) was used. This type of release has been modeled and found to result in the greatest ARF. The remaining three parameters are simply constants. This approach provides a conservative estimate of the dose such that it is unlikely that a greater dose would result from the scenarios postulated.

EXPOSURE PATHWAYS AND METHODOLOGY

The direct radiation pathway is shown in Equation (1) below:

$$\text{DOSE (mrem/yr)} = DCF_{i1} \times \text{Bulk Density} \times \text{Source Conc.} \times EF \times FA_1 \times FS \quad (1)$$

DCF_{i1} = (mrem/yr)/(pCi/cm^3).
Bulk Density of soil where a default value of 1.8 g/cm^3 is used.
Source Term = Picocuries per Gram of Soil for the ith radionuclide. Other variables are as they appear in the tables above.

The inhalation of resuspended dust pathway is shown in Equation (2) below:

$$\text{DOSE (mrem/yr)} = ASR \times FA_2 \times FCD_i2(t) \times EF \times FI_2 \times \text{Source Term} \times DCF_{i2} \quad (2)$$

ASR = Air-to-Soil resuspension factor, 2×10^{-4} g/m^3 is typically used (U. S. DOE, 1989).

DOSE AND RISK RESULTS

The purpose of this section is to integrate the source term characterization, the exposure scenario descriptions, and the pathway analysis methodology and then estimate the resulting doses and risks. There were three exposure scenarios identified in the introduction, numbered as (1), (2), and (3). Over these three exposure scenarios, doses and risks were calculated for the Plant 2/3 facility, the surrounding area, and the potential for exposure to the general population. The results will appear as follows:

TABLE 5:DOSE AND RISK RESULTS SCENARIO #1
[DIRECT RADIATION EXPOSURE]

Contaminant	Source (pCi/cm^2)	DOSE (mrem)	RISK**
uranium - (234 & 238)	3.2×10^{5}	70	7×10^{-5}
thorium - 230	3.2×10^{2}	3×10^{-3}	3×10^{-9}
radium - 226	3.2×10^{2}	5	5×10^{-6}
Total	N/A	75	7×10^{-5}

** - Risk factor is assumed to be 1×10^{-6} Risk per mrem (approximately the value found in BEIR V)

TABLE 6:DOSE AND RISK RESULTS FOR SCENARIO #2
[DIRECT RADIATION EXPOSURE]

Contaminant	Source (pCi/cm^2)	DOSE (mrem)	RISK**
uranium - (234 & 238)	2.0×10^{2}	2×10^{-2}	2×10^{-8}
thorium - 230	2.0×10^{-1}	7×10^{-7}	7×10^{-13}
radium - 226	2.0×10^{-1}	1×10^{-3}	1×10^{-9}
Total	N/A	2×10^{-2}	2×10^{-8}

TABLE 7:DOSE AND RISK RESULTS FOR SCENARIO #2
[INHALATION OF PLUME]

Contaminant	Df * ARF (S/m^3)	Inh (m^3)	DOSE (mrem)	Risk
U (234 & 238)	0.0075	0.96	4×10^{-4}	4×10^{-10}
Th - 230	7.5×10^{-6}	0.96	4×10^{-7}	4×10^{-13}
Ra - 226	7.5×10^{-6}	0.96	1×10^{-8}	1×10^{-14}
Total			4×10^{-4}	4×10^{-10}

TABLE 8:DOSE AND RISK RESULTS FOR SCENARIO #2
[INHALATION FROM RESUSPENDED DUST]

Contaminant	CA surf conc. (pCi/cm^2)	EF	DOSE (mrem)	Risk
U (234 & 238)	2.0×10^{2}	33.2	0.2	2×10^{-7}
Th - 230	2.0×10^{-1}	33.2	2×10^{-4}	2×10^{-10}
Ra - 226	2.0×10^{-1}	33.2	5×10^{-6}	5×10^{-12}
Total	N/A	N/A	0.2	2×10^{-7}

TABLE 9:DOSE AND RISK RESULTS FOR SCENARIO #3
[DIRECT RADIATION EXPOSURE]

Contaminant	Source (pCi/cm^2)	DOSE	RISK**
uranium - (234 & 238)	1.2×10^{1}	2×10^{-2}	2×10^{-8}
thorium - 230	1.2×10^{-2}	6×10^{-7}	6×10^{-13}
radium - 226	1.2×10^{-2}	1×10^{-3}	1×10^{-9}
Total	N/A	2×10^{-2}	2×10^{-8}

TABLE 10:DOSE AND RISK RESULTS FOR SCENARIO #3
[INHALATION OF PLUME]

Contaminant	Df * ARF (S/m^3)	Inh (m^3)	DOSE (mrem)	Risk
U (234 & 238)	1.1×10^{-4}	0.96	3×10^{-5}	3×10^{-11}
Th - 230	1.1×10^{-7}	0.96	3×10^{-8}	3×10^{-13}
Ra - 226	1.1×10^{-7}	0.96	8×10^{-10}	8×10^{-15}
Total	N/A	N/A	3×10^{-5}	3×10^{-11}

TABLE 11:DOSE AND RISK RESULTS FOR SCENARIO #3
[INHALATION FROM RESUSPENDED DUST]

Contaminant	CA surf conc. (pCi/cm^2)	EF	DOSE (mrem)	Risk
U (234 & 238)	1.2×10^{1}	399	0.2	2×10^{-7}
Th - 230	1.2×10^{-2}	399	2×10^{-4}	2×10^{-10}
Ra - 226	1.2×10^{-2}	399	5×10^{-6}	5×10^{-12}
Total	N/A	N/A	0.2	2×10^{-7}

SUMMARY/DISCUSSION OF RESULTS

Doses and risks were estimated for three exposure scenarios resulting from a hypothetical release of contamination in and around Plant 2/3. The total source term and the overall extent was determined using known concentrations of uranium within the uranyl nitrate that could be released from Plant 2/3. The first exposure scenario was identified as an external radiation pathway which occurs as the receptor, a reasonable maximumally exposed individual for this pathway, is engaged in all of the anticipated activities identified for safe shutdown. This particular scenario assumes the individual is exposed in a fashion which involves only external radiation since workers are required to have the appropriate personal protective clothing. The second exposure scenario was identified as an on-site worker who is not involved in any of the safe shutdown activities but is within 100 meters of a particular release. Exposure scenario (2) incorporates both the external radiation pathway and two types of inhalation (direct plume and resuspension of contaminated dust). The final exposure scenario, number (3), considers the potential for exposure to the general public via the fugitive dust pathway. The estimate of the airborne concentrations of the various contaminants was based on a dilution factor and the airborne respirable fraction.

The total annual risks for each exposure scenario are shown below:

TABLE 12:TOTAL DOSE AND RISK FOR EACH SCENARIO

SCENARIO	DOSE	RISK
#1	76	8×10^{-5}
#2	2×10^{-1}	2×10^{-7}
#3	2×10^{-1}	2×10^{-7}

Workers involved in the Safe Shutdown activities will have their radiation exposures kept ALARA via the use of administrative, engineering, and personal protective equipment controls. Work activities will be maintained consistent with the requirements listed in the Radiological Controls Manual (RM-0009 and DOE/EH-0256T). Maximum exposure to any individual will not be permitted to exceed 3 Rem annual committed dose equivalent and maximum exposure to any individual off-site will not exceed 100 mRem annual committed dose equivalent.

4.0 ASSESSMENT OF NEED FOR A REMOVAL ACTION

Consistent with Section 40 CFR 300.410 of the National Contingency Plan, the Department of Energy (DOE) shall determine the appropriateness of a removal action. Eight factors to be considered in this determination are listed in 40 CFR 300.415 (b) (2). The following apply specifically to the conditions to be addressed by the Safe Shutdown Program.

40 CFR 300.415 (b) (2) (i)

> Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants.

40 CFR 300. 415 (b) (2) (ii)

> Actual or potential contamination of drinking water supplies or sensitive ecosystems.

40 CFR 300. 415 (b) (2) (iii)

> Hazardous substances or pollutants or contaminants in drums, barrels, tanks or other bulk storage containers that may pose a threat or release.

40 CFR 300. 415 (b) (2) (v)

> Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released.

40 CFR 300. 415 (b) (2) (vii)

> The availability of other appropriate federal or state response mechanisms to respond to the release.

40 CFR 300. 415 (b) (2) (viii)

> Other situations or factors that may pose threats to public health or welfare or the environment.

5.0 APPROPRIATENESS OF A RESPONSE

The driving force for the appropriateness of a response is 40 CFR 300.415 (b) (3), and 40 CFR 300.415 (b) (4) (i) and (ii).

If it is determined that a response action is appropriate due to conditions within the former process area, a removal action may be required to address the existing situation.

If a planning period of less that six months exists prior to initiation of a response action, DOE will issue an Action Memorandum. The Action Memorandum will describe the selected response and provide supporting documentation for the decision.

If it is determined that there is a planning period greater than six months before a response is initiated, DOE will issue an Engineering Evaluation/Cost Analysis (EE/CA) Approval Memorandum. This memorandum is to be used to document the threat of a public health and the environment and to evaluate viable alternatives response action. It will also serve as a decision document to be included in the Administrative Record.

ATTACHMENT I

SAMPLING PLAN LISTING- ALL OTHER MATERIALS

BUILDING: 1

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
016	Copper	Copper Shredder	0	0	0	E109
200	UO3	Cyclone	1	500	28	E112
013	Chlorinated solvent	Detrex Still	1	48	6	E107
---	No holdup possible	Drum Straightening Equipment	0	0	0	E101
156, 157	UO2, UO3	Fitzpatrick, Thor & Zenith Mills	0	0	0	E105
003, 001	Paint	Paint Booth	1	250	31	E104
016, 034, 035, 170, 156, 157, 155, 029, 066	U3O8, UO3, UO2, U concentrates, MgF2, copper	Plant 1 Dust Collectors	70	42,000	3,850	E111
150, 025, 072	UNH, HNO3	Safe Geometry & Lab Digestion	1	115	13	E108

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 1

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
170	U concentrates	Thaw Tunnel	0	0	0	E110
034, 035	MgF2, U, sump cake	Titan Mill	7	4,200	385	E106
021	Steel shot, drum residue	Wheelabrator	2	2,000	110	E102

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 2/3

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
072	UNH	Combined Raffinate Area: Evaporator and Feed Tanks	0	0	0	E213
007	Nitrate salt solution	Combined Raffinate Area: Raffinate Tanks	0	0	0	E211
072	UNH	Combined Raffinate Area: UNH Tanks	0	0	0	E210
200	UO3	Denitration Pots	1	900	55	E222
204, 029, 072	UNH	Digesters, Hold Tanks, Blend Tanks, Hot Raff Area, UNH Tanks	2,060	1,133,000	113,300	E201
---	Dilute nitric acid	Dilute Nitric Acid Tanks	0	0	0	E212
072	TBP/Kerosene	Extraction Columns, Tanks, Solvent Handling Centrifuges, Mixer/Settler	0	0	0	E214

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 2/3

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
---	Sulfuric acid	Extraction Deionizer Acid Tank	0	0	0	E216
---	Caustic	Extraction Deionizer Caustic Tank	0	0	0	E217
---	Ion exchange resin	Extraction Deionizer System	0	0	0	E215
200, 029	UO3	Gulping Equipment and Dust Collectors	20	18,000	1,100	E223
012	Dilute nitric acid	Harshaw System	0	0	0	E209
001	Caustic soda	Hot Raffinate Area Caustic Tanks/Scrubbers	0	0	0	E208
001	Lime slurry	Hot Raffinate Area Lime Tank	0	0	0	E207
067	MgF2 sludges	Hot Raffinate Area Tanks, Filter	0	0	0	E206

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 2/3

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
022	Kerosene	Kerosene Tank	0	0	0	E218
---	Dilute HNO3	NAR System	0	0	0	E224
204	UNH	NFS Storage Tanks	1,700	935,000	93,500	E221
---	HNO3	Nitric Acid Tanks	500	275,000	27,500	E203
204	UNH	OK Liquor Tanks, Evaporation Tanks, Evaporators	220	121,000	12,100	E220
164	MgO precipitated uranium	RTS System	70	35,000	3,850	E226
012	Dilute HNO3	Scrubber System, Acid Tank	40	20,000	2,200	E204
154, 155, 159, 162, 164, 062, 029	U3O8, sump cakes, dust collector residues	Solids Handling Equipment: Conveyors, Drum Dumpers, Bucket Elevators, Dust Collectors	5	3,000	275	E205

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 2/3

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
022	TBP/Kerosene	Solvent Separation Equipment: Tanks,Filters, etc.	10	4,400	550	E202
022	TBP	TBP Tank	0	0	0	E219
022	TBP/kerosene	TBP/Kerosene Tank	170	74,800	9,350	E225

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 39A

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
032, 033	U308, ash	Kelly Incinerator	1	500	55	E704
048	U308, ash	Trane Incinerator	1	500	55	E705

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 4

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
---	NH3	Ammonia Dissociators	0	0	0	E407
001	Dilute HF	HF Feed and Recovery System	80	36,000	4,400	E406
132, 029	UO2, UO3, U3O8, UF4	Plant 4 Dust Collectors	20	20,000	1,100	E405
210	UF4	UF4 Handling Equipment	2	2,000	110	E404
210	UF4	UF4 Reactors	2	2,000	110	E403
200, 214	UO3, U3O8	Uranium Oxide Handling Equipment	2	1,800	110	E401
165	U3O8	Uranium Oxide Reactors	1	504	31	E402

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 5

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
030, 100	U, graphite, U308, mold and crucible coating	Casting Furnaces	6	2,871	287	E506
009, 110, 111	U chips, coolant, carbide tips	Circular Saws and Blade Sharpener	1	52	4	E510
057	U, MgF2, UF4, Mg	Cooling Wells	1	102	9	E505
029, 030, 062, 100, 132	UF4, U, Mg, MgF2, U308, mold and crucible coating, graphite particles, Black Beauty grit cleaner	Dust Collectors	13	7,800	715	E511
035-038	MgF2, UF4, Mg	F-Machines	1	198	18	E504
015, 020	Vacuum oil	Hilco System	15	6,398	800	E508
030, 100	U, graphite, mold & crucible coating, U308	Ingot and Graphite Handling Equipment	2	666	67	E507
035-038	MgF2	Jolters & Bins	70	42,000	3,850	E503

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 6

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
039	Oil, sludge	Coolant System	10	4,545	500	E606
010, 060, 044, 100	KCl, NaCl, U3O8, Oil	Heat Treat Furnaces & Quench Tanks	6	3,000	330	E601
009, 110, 111	Coolant, U chips	Machining & Chip Handling Equipment	1	600	55	E603
---	Na2S (never used in equipment)	NOx Destructor	0	0	0	E608
041	U3O8, sludge, HNO3	Pickling Equipment	0	0	0	E605
029	U3O8	Plant 6 Dust Collectors	15	8,250	825	E604
061, 100	K2CO3, Li2CO3, U3O8	Rolling Mill & Heating Furnaces	273	179,995	15,000	E602
009	Water-soluble Oil, caustic precipitated U	Water Treatment System	48	21,600	2,640	E607

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 8

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
154	U3O8, miscellaneous ash	Box Furnace	0	0	0	E807
---	Caustic	Caustic Tank	360	244,800	19,800	E801
021	Drum residue	Drum Washer	2	1,000	110	E809
001, 002, 069	Lime-precipitated uranium	Oliver Filter	0	0	0	E802
100, 121, 153, 154	U3O8	Oxidation Furnace #1	6	5,100	330	E803
082	UF4, lime	Oxidation Furnace #2	6	3,720	330	E804
029, 062, 132	U3O8	Plant 8 Dust Collectors	25	13,750	1,375	E811
143	Roasted cake	Primary Calciner	25	12,500	1,375	E805
002, 003, 143, 144	Roasted cake	Rotary Kiln	6	3,000	330	E806

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 8

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
082, 098, 100, 101, 122	U3O8	Rotex Screen	0	0	0	E808
---	Precipitated U residue	Williams Mill	0	0	0	E810

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 9

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
030, 100	Graphite, U3O8, mold and crucible coating	Casting Furnaces	2	1,100	110	E903
044, 045, 061, 100	K2CO3, Li2CO3, U3O8	Derby Cleaning Furnace & Quench Tank	5	2,996	250	E901
015, 020	Vacuum oil	Hilco System Equipment	5	1,918	240	E905
030, 100	U, graphite, mold and crucible coating, U3O8	Ingot and Graphite Handling	1	99	10	E904
009, 039	Coolant	Machining and Chip Handling Equipment	10	4,550	501	E908
029, 030, 062, 100, 132	UF4, MgF2, U3O8, mold and crucible coating, graphite particles, Black Beauty grit cleaner	Plant 9 Dust Collectors	1	600	55	E907
034-038, 070, 071, 077, 084	MgF2, UF4, Mg	Reduction Furnaces	10	6,000	550	E902

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: 9

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
072	HCl, HNO3	Zirnlo Process	0	0	0	E906

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: BP

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
049	U308, ash	Graphite Burner	1	100	11	E703
048	U308, ash	Oil Burner	1	100	11	E702

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: PP

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
015	Vacuum Oil	Hilco System	2	880	110	E310
---	NH3	NH3 Dissociators	0	0	0	E303
---	HNO3	Nitric Acid Tank	5	2,750	275	E313
140	Zirconium oxide	Plasma Spray	1	20	2	E308
100	U3O8	Shot Blaster	1	650	55	E307
210, 029	UF4 product	UF4 Packaging Equipment and Dust Collectors	8	8,000	440	E304

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.

BUILDING: STP

Material Type Code	Chemical Description	Equipment Description	Holdup- Drum Equivalents	Holdup- Pounds**	Holdup- Gallons**	Sampling Plan Number
032, 033	U308, ash	Incinerator	1	400	44	E701

** Based on estimated volumes and weights. See letter, WEMCO:E(SE):92-031.