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Formerly Utilized Sites Remedial Action Program (FUSRAP)

ADMINISTRATIVE RECORD

for Maywood, New Jersey

U.S. Department of Energy

0489-0613.1

93-666 107671

Department of Energy

Oak Ridge Operations
P.O. Box 2001
Oak Ridge, Tennessee 37831— 8723

August 23, 1993

Mr. George Pavlou, Acting Director
Emergency & Remedial Response Division
U.S. Environmental Protection Agency
Region II
Jacob K. Javits Federal Building
26 Federal Plaza
New York, New York 10278

Mr. Lester K. Price, Director
Former Sites Restoration Division
U.S. Department of Energy
Oak Ridge Operations Office
P. O. Box 2001
Oak Ridge, Tennessee 37831

Dear Dispute Resolution Committee:

MAYWOOD SITE - CLEANUP CRITERIA DISPUTE - SUPPLEMENTAL INFORMATION

The purpose of this letter is to transmit the Department of Energy's (DOE's) revised documentation illustrating the protectiveness of the proposed cleanup criteria for the site-specific conditions at the Maywood site. This information is presented in the enclosed document entitled, "Assessment of Residual Radioactive Contamination at the Maywood Site" (Attachment A). A previous draft of this document was submitted to the Environmental Protection Agency (EPA) on August 9, 1993, and has been further revised based on subsequent discussions.

Predicted risks from residual radioactive contaminants in site soils following remediation are estimated to be well below DOE's primary dose limit of 100 mrem/year and within EPA's target risk range of 10^{-6} to 10^{-4}, based upon the following cleanup criteria and assumptions:

- Soils to be remediated include those containing concentrations of thorium-232 and/or radium-226 greater than 5 pCi/g in the surface 15-cm layer of soils and greater than 15 pCi/g in any 15-cm layer of soil below the surface layer.

- Clean soil from an appropriate borrow area would be used as surface fill at all properties.

- During Phase II of the proposed remedy, contaminated soils would undergo a physical treatment process, and treated soils with residual radionuclide concentrations below 15 pCi/g would be used for subsurface fill material at the Maywood Interim Storage Site, the Stepan Company property, and possibly at adjacent commercial/industrial properties. The replaced soils would be covered by a surface layer of at least 0.3 m (1 foot) of clean soil from an appropriate borrow area.

- Intrusion into either the residual contaminated soils or replacement soils as a result of reasonable construction scenarios has been explicitly evaluated and determined to meet the same dose and risk limits.

The revised analysis should address the issues and concerns raised during our meeting of August 3, 1993. If you have any questions or require further information please call me at (615) 576-5724.

Sincerely,

Susan M. Cange

Susan M. Cange, Site Manager
Former Sites Restoration Division

Enclosure

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ATTACHMENT A

Assessment for Residual Radioactive Contamination at the Maywood Site

(Revision 2 - August 23, 1993)

A.0 Summary

The U.S. Department of Energy proposes to remediate radioactively contaminated soils at the Maywood site to concentrations that result in residual risks that are conservatively estimated to be within the Environmental Protection Agency's target risk range of 10^{-6} to 10^{-4} specified in the National Contingency Plan. The approach is (1) to reduce the source of contamination to levels used for similar situations, and (2) to eliminate or reduce pathways for transport and exposure by providing additional soil cover over residual contamination. Receptor scenarios are based on reasonable future land use and additional controls and restrictions are not imposed. The analyses indicate that adding additional soil cover over the residual contaminated soils is an effective approach to reducing risk.

Soils containing radionuclide concentrations greater than 5 pCi/g above background of thorium-232 and/or radium-226 in the surface 15-cm layer and greater than 15 pCi/g above background in any 15-cm layer below the surface layer would be remediated. During Phase II of the proposed remedy, excavated soils would be treated using a physical separation process, and treated soils with residual radionuclide concentrations (thorium-232 + radium-226) less than 15 pCi/g would be replaced as subsurface backfill at the MISS, Stepan Company property, and possibly adjacent commercial/industrial properties. These replacement soils would be covered with clean soil to a depth of at least 0.3 m (1 ft). At other properties only clean soil would be used for fill material at all depths. In all cases, predicted radiation doses are below the DOE's primary dose limit of 100 mrem/year effective dose equivalent, and the estimates of excess cancer risk are within the EPA's 10^{-6} to 10^{-4} target risk range.

The provision of a clean soil cover of 0.3 m (1 ft) or greater is a reasonable risk management approach and is preferred over additional reductions in residual concentration limits; due to the nature of the contaminant distribution at most vicinity properties (particularly residential properties), the residual contaminated soils would generally be at depths greater than 1 m (3 ft) following remediation, providing an additional measure of safety. The risk estimates are based on conservative assumptions regarding the extent and concentration of residual contaminants (i.e., residual concentrations assumed for the analysis are significantly higher than those achieved in previous cleanup actions at the Maywood site, and higher than the area-averaged pre-remediation soil concentrations), reasonable maximum exposure parameters for resident and employee receptors, and evaluation of future excavation intrusions into the contaminated zone.

Evaluation of key sensitivities, such as the mix of contaminants, extent of contamination, and radiation shielding assumptions, indicate that the scenarios provide conservative estimates of potential dose and risk, and provide a reasonable basis for decision making.

A.1 Introduction

This analysis presents estimates of radiation dose and incremental cancer risk to potential receptors following remediation of the Maywood site to the cleanup criteria proposed in the "Feasibility Study-Environmental Impact Statement for the Maywood Site" (DOE 1993a) and the "Proposed Plan for the Maywood Site" (DOE 1993b). These dose and risk estimates were computed using the RESRAD computer code (Gilbert et al. 1989, Yu et al. 1993a), which has been developed to implement the DOE guidelines for residual radioactive material as specified in DOE Order 5400.5 (DOE 1990). Parameter values and assumptions conform with those in the "Baseline Risk Assessment for the Maywood Site" (DOE 1993c), which has been formally approved by EPA, and in the Feasibility Study, except as specifically discussed below.

For the purpose of evaluating residual risks following remediation, it is important to consider the specific characteristics of the Maywood site, particularly with respect to distribution of contaminants at the affected properties. The residual risk analysis considers two primary categories of properties, based on contaminant distributions and current and future land use:

o The majority of affected properties (i.e., vicinity properties) are thought to have become contaminated as a result of surface water migration from the former Maywood Chemical Works through Lodi Brook; contaminants were deposited along the stream channel and associated floodplains. Subsequent development of these properties included significant fill and grading operations, in which the former stream channel and contaminated soils were covered with up to 10 feet of clean fill. Due to the location of contamination at these properties, remediation will require excavation to the depth of contamination, followed by backfilling with clean soil from an offsite borrow area. Any residual contamination left in place below cleanup criteria, therefore, would be covered by a substantial layer of clean soil. For these properties, the residual risk analysis is based upon a residential land use scenario, as further discussed below.

o The Maywood Interim Storage Site, the Stepan Company property, and some adjacent vicinity properties which were more directly associated with the operations of the former Maywood Chemical Works have much different distributions of contaminants, in some cases including former lagoons and waste burial areas. Volumes and concentrations of contaminated soils at these properties are significantly greater than for the vicinity properties discussed above. Furthermore, the proposed remedy calls for excavation and treatment of contaminated soils, followed by replacement of soils treated to below residual criteria as subsurface backfill at MISS, Stepan, and adjacent vicinity properties (if necessary, depending on volume of treated soils); a residual radionuclide criterion of 15 pCi/g for the replacement soils has been determined to be protective of human health and the environment. A layer of 0.3 meter (1 ft) of clean soil from an off-site borrow area would be emplaced as a surface cover. For these properties, which have been under heavy commercial/industrial use for many years, future residential land use is not considered likely, and the residual risk analysis is based upon a commercial/industrial land use scenario, as further discussed below.

A.2 Source Term Assumed for Residual Risk Analysis

Under the proposed cleanup criteria, concentrations of thorium-232 and radium-226 (and their respective decay products) would not exceed 5 pCi/g above background in the surface 15-cm layer of soil or 15 pCi/g above background in any 15-cm layer below the surface layer. However, as noted above, clean surface fill will be used at all remediated properties, so the 5 pCi/g criterion for surficial soils would not be invoked; as discussed above, for the properties contaminated as a result of surface water migration along Lodi Brook, the depth of clean cover would typically be 1 to 2 meters. At properties where treated soils are replaced as subsurface backfill material, a minimum clean surface cover of at least 0.3 m (1 ft) will be provided. For the purpose of the residual risk evaluation, the 15 pCi/g residual concentration limit for radium and thorium in subsurface soils is assumed, allocated as indicated in Table A-1.

Table A-1. Assumed Residual Soil Concentrations

Radionuclide	Assumed Residual Soil Concentration Above Background (pCi/g)	
	Surface[a]	Subsurface
Th-232 + Progeny	0	12
Ra-226 + Progeny Th-230	0	3[b]
U-238 + Progeny, U-234	0	12[c]
U-235 + Progeny	0	0.6[d]

[a]Proposed remedy calls for clean surface fill at all remediated properties.
[b]Assumed 25% of Th-232 concentration, based on site characterization data.
[c]Assumed equal to Th-232 concentration, based on site characterization data.
[d]Assumed 5% of U-238 concentration, based on relative isotopic abundance.

This relative allocation is based on the relative magnitude of measured thorium-232, radium-226, and uranium-238 concentrations in soils at the Maywood site. The concentration of radium-226 is assumed to be approximately 25% of the thorium-232 concentration, based on a review of site characterization data (the radium-226:thorium-232 concentration ratio ranges from approximately 0.05 to 0.28 for residential properties, and from 0.005 to 0.26 for commercial/industrial properties, with a site-wide average of 0.23), and the composite concentration of radium-226 and thorium-232 is constrained to 15 pCi/g. Thorium-230 concentrations are assumed to be equivalent to radium-226 concentrations in soil. The 15 pCi/g limit is not applicable to uranium, for which a site-specific concentration limit is derived; however, a review of the site characterization data indicates that the uranium-238 concentration measurements in soil are similar to the thorium-232 concentrations (the uranium-238:thorium-232 ratio ranges from 0.35 to 1.7 for residential properties and from 0.14 to 3.3 for commercial/industrial properties, with a site-wide average of 1.0), and the concentration of uranium-238 and progeny is assumed to be equal to the residual thorium-232 concentration for evaluation of residual risk.

The residual radionuclide concentrations assumed for this analysis are considered to be extremely conservative based on an analysis of post-remediation characterization data at the vicinity properties cleaned up during 1984 and 1985. A review of these data indicate that residual concentrations of thorium-232 are generally below 5 pCi/g in the subsurface soils (i.e., in 1053 of the 1105 soil samples collected; average ≈ 2 pCi/g above background), and radium-226 and uranium concentrations are typically at or near background levels. Therefore, the source term considered in this analysis may be conservative by approximately a factor of 3 to 6. Furthermore, the residual radionuclide concentrations evaluated in this analysis are significantly higher than the pre-remediation radionuclide concentrations in soil as determined by the site characterization data; the site-wide upper 95% confidence limit mean soil concentrations are estimated as 4 pCi/g for thorium-232, 0.9 pCi/g for radium-226, and 4 pCi/g for uranium-238. Thus, the analysis of residual risks based on the upper bound of the soil concentration limit may overestimate the likely risks by a factor of 3 or more.

During Phase II of the remedial action for the Maywood site, excavated soils will be treated using a physical separation treatment process. Treated soils with residual radionuclide concentrations below 15 pCi/g for thorium-232 and radium-226 will be replaced as subsurface fill material at the MISS property, Stepan Company property, and possibly at adjacent commercial properties, whereas concentrated wastes from the treatment process will be transported for off-site commercial disposal. The 15 pCi/g treatment criteria is considered an upper bound, and treatment will be performed to levels as low as reasonably achievable, as determined by the technology capabilities and economics. Thus, the source term considered in this analysis for the treated replacement soils is also very conservative.

A.3 Residential Land Use Scenario

A.3.1 Exposure Assumptions

Exposure assumptions for the residual risk analysis were selected to maintain consistency with those previously approved by EPA in the Baseline Risk Assessment (DOE 1993c) where possible; parameters for which different assumptions were made to better reflect site-specific conditions are discussed below. Key parameter values assumed for the residual risk analysis are summarized in Table A-2. Parameter values assumed for site-specific geotechnical characteristics are summarized in Table A-3. As discussed below, the exposure assumptions are considered to be conservative, such that actual doses and risks are expected to be much lower than those estimated here.

Table A-2. Exposure Parameter Assumptions - Resident[a]			
Parameter	Units	Mean Resident	RME Resident
Exposure time indoors	h/d	16.4	16.4
Exposure time outdoors	h/d	0.44	0.44
Exposure frequency	d/yr	350	350
Exposure duration	yr	9	30
Area of exposure unit	m^2	300	300
Contaminated zone thickness	m	0.6	0.6
Depth of clean cover soil	m	0.15 - 1	0.15 - 1
Indoor gamma shielding factor Concrete floor slab Building walls	-	 0.3 0.85	 0.3 0.85
Inhalation rate	m^3/hr	0.62	0.83
Dust loading	$\mu g/m^3$	100	200
Dust from soil origin	%	50	50
Dust respirable fraction	%	30	30
Amount of outdoor dust present indoors	%	40	40
Soil ingestion rate	mg/d	60	100
Water ingestion rate	l/d	1.4	2.0
Fraction of drinking water from onsite well	-	1	1
Ingestion of home-grown produce	g/d	80	80

[a]The basis for assumed parameter values is discussed in the Baseline Risk Assessment (DOE 1993c), except as noted in text.

Table A-3. Site-Specific Geotechnical Assumptions[a]	
Parameter	Assumed Value
Contaminated zone total porosity	0.45
Contaminated zone hydraulic conductivity	1.23 m/yr (unsaturated)
Saturated zone total porosity	0.45
Saturated zone hydraulic conductivity	123 m/yr
Saturated zone hydraulic gradient	0.01
Unsaturated zone thickness	1 to 4.6 m (1 m assumed)
Unsaturated zone total porosity	0.45
Unsaturated zone effective porosity	0.26
Unsaturated zone hydraulic conductivity	1.23 m/yr
Precipitation Rate	1.07 m/yr
Runoff Coefficient	0.25
Dilution/Attenuation Factor [b]	100/500 ft
Soil-specific b parameter	5.3
Soil density	1.6 g/cm^3
Well pump intake depth	1 m
Soil erosion rate [c]	6 x 10^{-5} m/yr
Distribution coefficient, K_d [d]	Thorium - 60,000 Radium - 450 Uranium - 450 Lead - 900 Actinium - 1,500 Protactinium-2,500

[a]Assumed parameter values are taken from the Baseline Risk Assessment (DOE 1993c), except as noted.
[b]Radionuclide concentrations in groundwater are assumed to decrease by a factor of 100 for every 500 ft distance from the site.
[c]Reference: Yu et al. 1993b
[d]Reference: Baes et al. 1984; Sheppard and Thibault 1990

Site-specific data have been reviewed to better define the characteristics (area, depth, and thickness) of the contaminated zone that would be left following remediation. As noted previously, contaminated soils at most of the vicinity properties along the former course of Lodi Brook are located below substantial layers of clean fill material. Following excavation of contaminated soils, the excavation sites would be backfilled with clean soil (typically 1 to 3 m). For purposes of this analysis, it is conservatively assumed that 1 meter of clean fill would be emplaced over the residual contamination; results are also provided for a "minimum-cover" case, assuming a cover of only 0.15 m of clean fill. Site characterization data indicate that the area of the contaminated zone at the residential properties would be approximately 300 m^2, and the thickness of the residual contamination (i.e., the layer of soils with residual radionuclide concentrations below the 15 pCi/g criterion but above background) would be approximately 0.6 m. Surface soils are assumed to be subject to erosion, with an average erosion rate of 6×10^{-5} m/year (Yu et al., 1993b), representing a typical non-agricultural site with an average 2% slope.

Estimates of residual dose and risk are presented both for the conditions immediately following remediation, and also for the future time following remediation where the greatest residual risk is predicted, out to a period of 1000 years. While some further increases in residual dose and risk may be predicted at future times beyond 1000 years for some scenarios, the 1000-year period was selected as a reasonable maximum time horizon, as predictions at longer times become increasingly uncertain; impacts of different time horizons are discussed in the uncertainty analysis.

The effective shielding provided by buildings for the external gamma exposure pathway has been evaluated, based upon the actual gamma energies and intensities of the radionuclides of concern, various configurations of contaminated soil relative to the building, and the typical shielding provided by standard construction materials. For contaminated soils directly beneath buildings, an indoor shielding factor of 0.3 is assumed; this value represents the shielding that would be afforded by a 10-cm (4-in.) concrete slab (density=2.35 g/cm^3, half-value-layer [HVL]=6 cm for the maximum gamma energy of concern [Tl-208 2.6 MeV] and HVL=4 cm for the average gamma energy of the decay series [0.88 MeV]). Building walls are assumed to be less effective in shielding gamma radiation, with an effective indoor shielding factor of approximately 0.85, based on frame-siding construction; brick or masonary construction would provide additional shielding. Radiation shielding analyses have been performed using the MICROSHIELD (Grove 1992) computer code to support the shielding factors assumed for building floors and walls. Multiple configurations of contaminated soils relative to the location of the house were evaluated to ensure conservatism in the analysis, as depicted in Figure 1. Shielding geometry was analyzed by calculating the dose rate for a building occupant with contamination distributed beneath the building and outside the building using the RESRAD code. The results indicate that the dose rate is higher for the case with contamination directly beneath the building than for the case with the buiding covering only a portion of the contaminated area, i.e. allowing side shine radiation through walls. Thus for a given area of contamination, the reduction in dose rate due to increasing distance between the contaminated soils and the building is more important than the increase in dose rate due to the lower shielding afforded by the walls

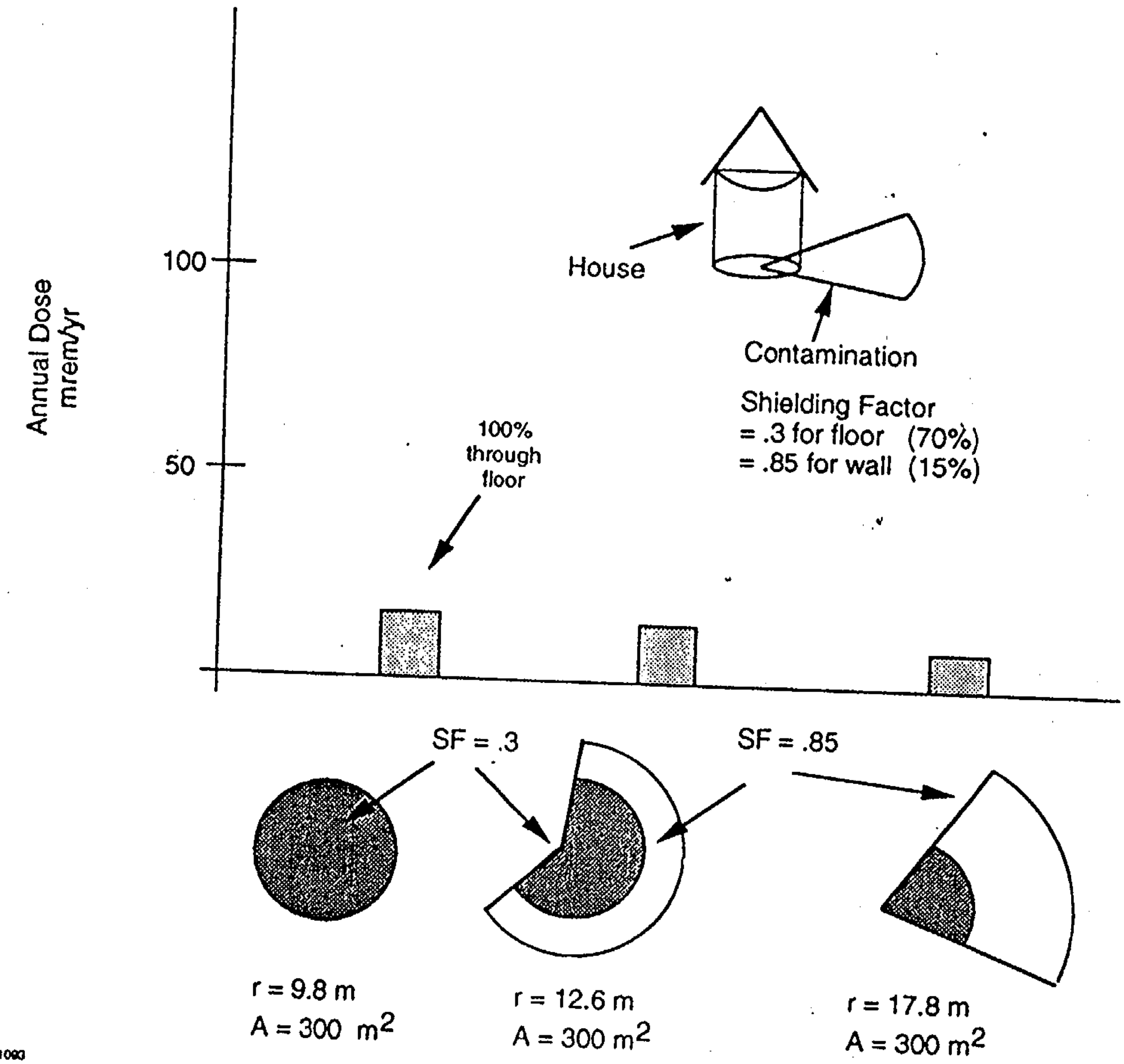

Figure 1. Comparison of Building Shielding Effects on External Gamma Dose Rate to an Indoor Receptor from Contaminated Soil Beneath and Outside the Building.

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relative to the floor; these results are consistent with recent recommendations of the U.S. Nuclear Regulatory Commission (NRC 1992), which provide a default value of 0.33 for the indoor shielding factor. These results indicate that the location of contaminated soils beneath the structure provides a reasonable maximum exposure estimate, and this is the assumed configuration in the dose and risk estimates presented below.

A.3.2 Estimates of Dose and Risk

Estimates of total effective dose equivalent and lifetime excess cancer risk to potential residents at the site following completion of remedial action are summarized in Table A-4. Results of this analysis indicate that the total effective dose equivalent from the residual soil contamination will not exceed the primary dose limit of 100 mrem/year (DOE 1990), under expected (mean) and reasonable maximum exposure (RME) conditions. Furthermore, estimates of excess cancer risk are within EPA's target risk range of 10^{-6} to 10^{-4}. These estimates are based upon conservative assumptions, such that actual doses and risks are expected to be lower.

Table A-4. Estimated Dose and Risk from Residual Soil Contamination - Resident

Resident Scenario	Effective Dose Equivalent (mrem/year)	Lifetime Excess Cancer Risk
Expected-Condition[a]		
Mean	1.2 (1.5)[c]	1×10^{-6} (1×10^{-6})[c]
RME	1.2 (1.8)[c]	6×10^{-6} (6×10^{-6})[c]
Minimum-Cover[b]		
Mean	16 (21)[c]	4×10^{-5} (6×10^{-5})[c]
RME	16 (22)[c]	1×10^{-4} (2×10^{-4})[c]

[a]Expected condition: 1 meter clean cover over residual contamination.
[b]Minimum-cover conditions: 0.15 m clean cover over residual contamination.
[c]First value represents time=0; parenthetical value is maximum dose/risk over the period of analysis (t=1000 years), if different from t=0.

Under expected conditions, the 1-meter clean soil cover over residual contaminants significantly limits potential exposure pathways. Direct gamma exposure is effectively shielded by the uncontaminated surficial soils and only small quantities of radon are released through the surface soils to contribute to the effective dose equivalent; at distant times groundwater ingestion is predicted to become the dominant exposure pathway. Under the assumed minimum-cover conditions (i.e., 0.15 m clean soil cover over contaminated zone), external gamma exposure is the dominant exposure pathway (~70%), with a significant contribution from ingestion of homegrown produce from a home garden (~29%); the later contribution to dose is due almost exclusively to lead-210 and is considered to be particularly conservative. Since

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the exposure parameters impacting the external dose rate estimates do not differ for the mean and RME conditions, the mean and RME estimates of effective dose equivalent are not significantly different; differences in mean and RME estimates of excess cancer risk are more pronounced due to the different exposure durations.

A.3.3 Intrusion

Potential dose and risk which might result from intrusion into the residual contaminated soil during construction activities at the affected properties was also evaluated. For the residential properties, this analysis considered excavation of a basement of assumed dimensions 9 m x 12 m x 2 m (30 ft x 40 ft x 6.5 ft), as depicted in Figure 2. Excavated soils were assumed to be spread on the ground surface surrounding the excavation site, with an average depth of approximately 0.3 m (1 ft) over an area of approximately 1000 m^2 (0.25 acre). Since the thickness of the contaminated zone at the residential properties is small relative to the depth of excavation, the radionuclide concentrations in the residual soils would be mixed with the uncontaminated cover material and clean soil beneath the contaminated zone. This effect would apply to both cover depths considered in Section A.3.2, and the estimated dose and risk are not significantly different for either cover scenario. Surface cover by clean topsoil would likely be added to support vegetation; such a topsoil layer would provide some reduction in predicted exposure rates and resultant risks, but was not considered in this analysis.

Predicted dose rates and residual risks to a resident at this property are summarized in Table A-5. The maximum dose rate and risk are predicted to occur immediately following remediation for both the mean and RME receptor conditions. External gamma exposure is predicted to be the dominant exposure pathway (~85%), with smaller contributions from the plant ingestion, particulate inhalation, soil ingestion, and radon inhalation pathways. The predicted dose rate is well below the primary dose limit of 100 mrem/year, and the residual risk estimate is still within EPA's target risk range. These estimates are considered to be highly conservative, due to the assumptions of spreading all excavated soils at the ground surface (as opposed to use as subsurface fill in some areas) and the assumed absence of a clean topsoil cover.

Table A-5. Estimated Dose and Risk from Residential Basement Excavation Scenario

Receptor Scenario	Effective Dose Equivalent (mrem/year)	Lifetime Excess Cancer Risk
Resident		
Mean	23	7×10^{-5}
RME	24	2×10^{-4}

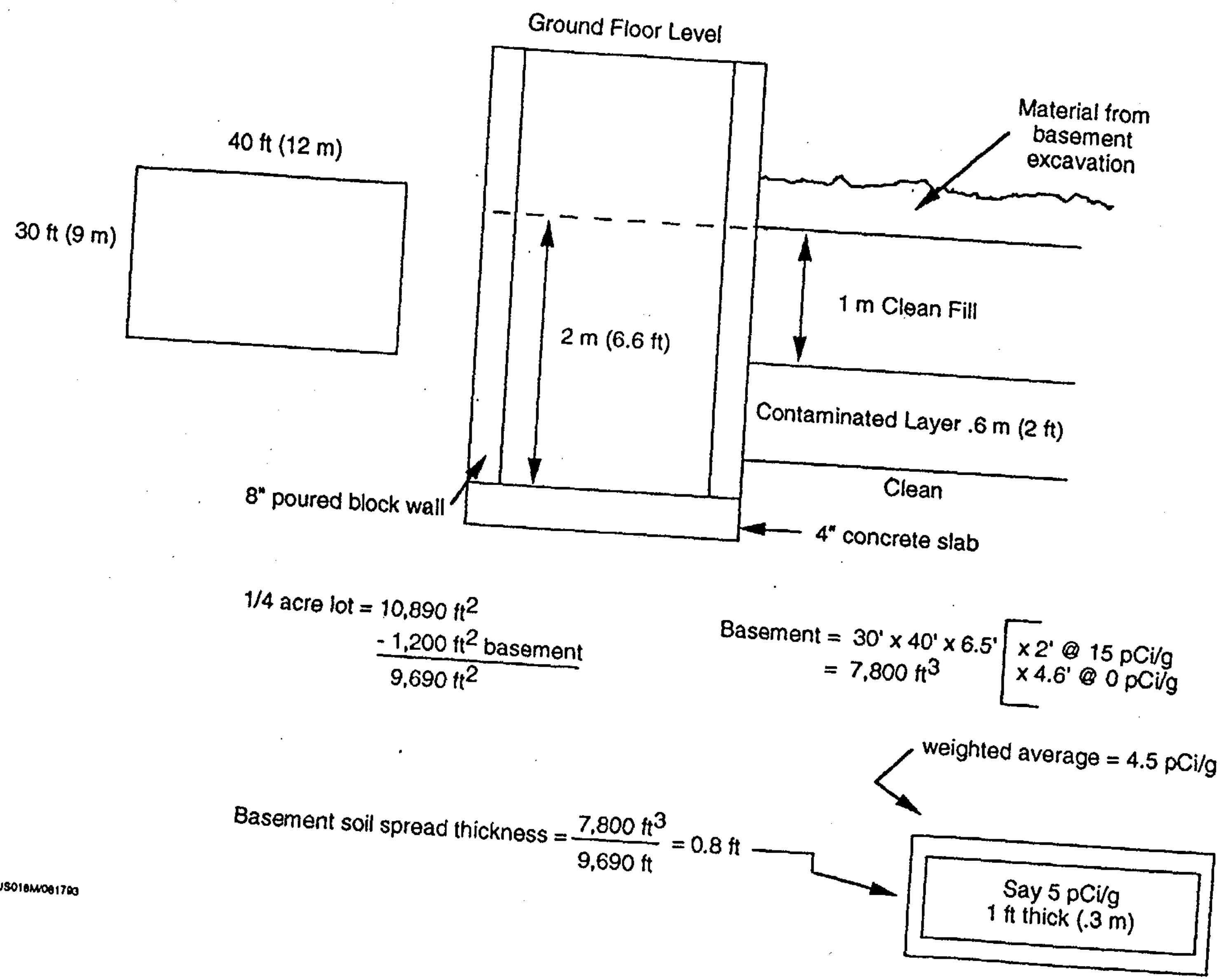

Figure 2. Intrusion Scenario for Residential Vicinity Properties - Basement Excavation/Redistribution.

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A.4 Commercial/Industrial Land Use Scenario

A.4.1 Exposure Assumptions

As noted in Section A.1 and discussed in the Baseline Risk Assessment, future residential land use was not considered for the MISS, Stepan, and adjacent heavily industrial/commercial properties. Therefore, a commercial/industrial land use scenario was evaluated for these properties. As for the case of the residential land use scenarios, exposure assumptions for the residual risk analysis for these properties were selected to maintain consistency with those previously approved by EPA in the Baseline Risk Assessment (DOE 1993c) where possible, with some changes to better reflect site-specific conditions as discussed below. Parameter values assumed for the residual risk analysis for these properties are summarized in Table A-6. Geotechnical parameters are the same as for the residential scenario (Table A-3).

The characteristics of the contaminated zone that would be left following remediation are considerably different for some of the commercial/industrial properties. The proposed remedy calls for excavation of contaminated soils, treatment using a physical separation technology, and replacement of treated soils on-site as subsurface backfill, which would be covered by 0.3 m (1 ft) of clean soil. For purposes of this analysis, the contaminated zone is assumed to be 1000 m^2 in area, with a thickness of 2 m. While the actual areas of residual contamination at some locations may be slightly larger, these values are considered to adequately characterize the exposure area for a given employee. Further, the analysis of residual risk is very insensitive to further increases in the areal extent and thickness of the contaminated zone beyond these levels. Under the expected conditions, residual soils are assumed to be covered by clean fill to a depth of 0.3 m (1 ft); a mimimum-cover scenario is also evaluated assuming a clean cover depth of 0.15 m (6 in.).

The average erosion rate assumed for the commercial/industrial scenario is the same as that for the residential scenario, at 6 x 10^{-5} m/year (Yu et al., 1993b), representing a typical non-agricultural site with an average 2% slope.

The effective shielding provided by buildings is also considered in the same manner as for the residential scenario, with effective shielding factors of 0.3 for the floors and 0.85 for the remainder of the structure, as discussed in Section A.3.1.

A.4.2 Estimates of Dose and Risk

Estimates of total effective dose equivalent and lifetime excess cancer risk to potential employees at the site following completion of remedial action are summarized in Table A-7. Results of this analysis indicate that the total effective dose equivalent from the residual soil contamination will not exceed the primary dose limit of 100 mrem/year (DOE 1990), under expected (mean) or reasonable maximum exposure (RME) conditions. Furthermore, estimates of excess cancer risk are within the EPA's target risk range of 10^{-6} to 10^{-4}. These estimates are based upon conservative assumptions, and actual doses and risks are expected to be lower.

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Table A-6. Exposure Parameter Assumptions - Employee[a]			
Parameter	Units	Mean Employee	RME Employee
Exposure time indoors	h/d	7	7
Exposure time outdoors	h/d	1.75	1.75
Exposure frequency	d/yr	250	250
Exposure duration	yr	7	25
Area of exposure unit	m^2	1000	1000
Contaminated zone thickness	m	2	2
Depth of clean cover soil	m	0.15 to 0.3	0.15 to 0.3
Indoor gamma shielding factor Concrete floor slab Building walls	-	 0.3 0.85	 0.3 0.85
Inhalation rate	m^3/hr	1.875	2.5
Dust loading	$\mu g/m^3$	100	200
Dust from soil origin	%	50	50
Dust respirable fraction	%	30	30
Amount of outdoor dust present indoors	%	40	40
Soil ingestion rate	mg/d	30	50
Water ingestion rate	l/d	0.7	1.0
Fraction of drinking water from onsite well	-	1	1
Ingestion of home-grown produce	g/d	-	-

[a]The basis for assumed parameter values is discussed in the Baseline Risk Assessment (DOE 1993c), except as noted in text.

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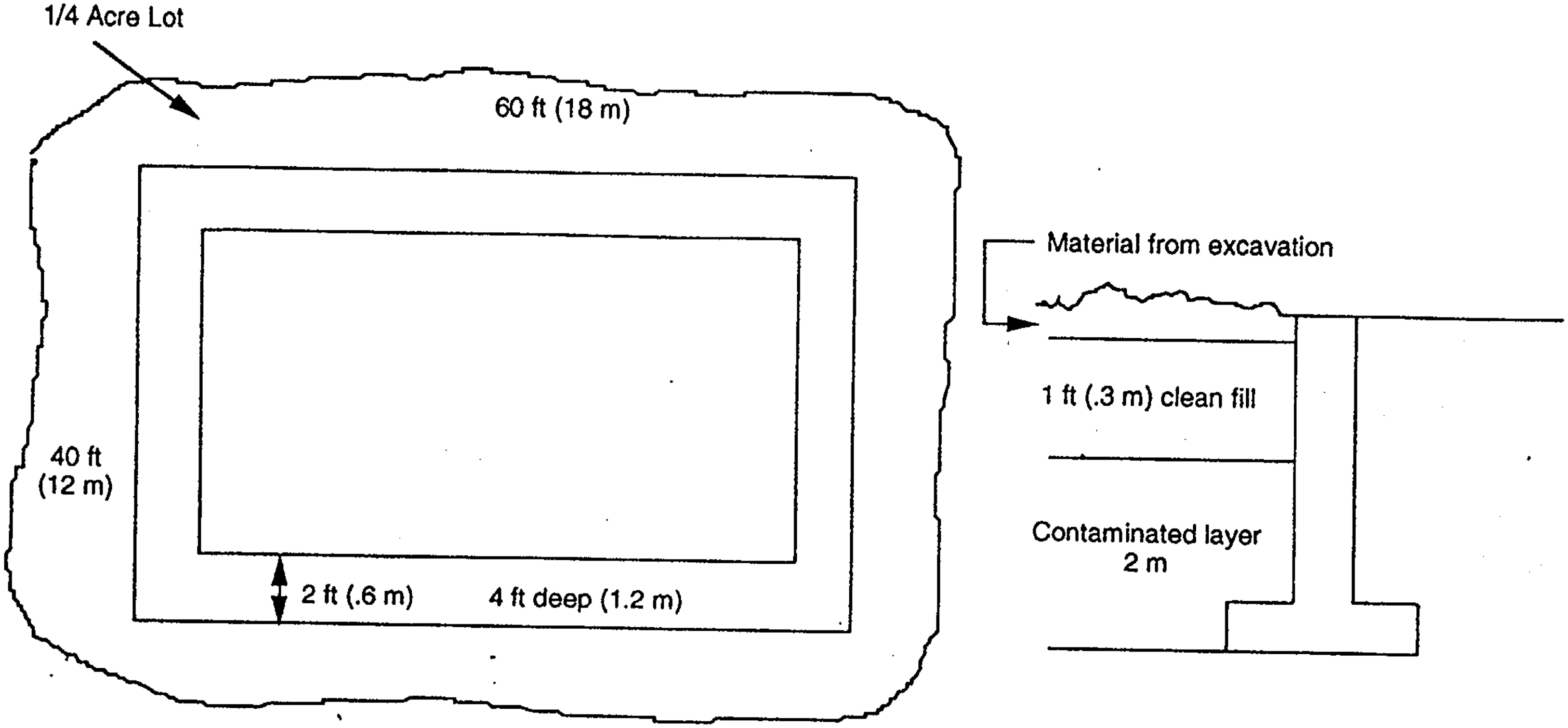
Table A-7. Estimated Dose and Risk from Residual Soil Contamination - Employee		
Employee Scenario	**Effective Dose Equivalent (mrem/year)**	**Lifetime Excess Cancer Risk**
Expected Conditions[a]		
Mean	2 (4)[c]	6×10^{-6} (1×10^{-5})[c]
RME	2 (4)[c]	2×10^{-5} (4×10^{-5})[c]
Minimum-Cover[b]		
Mean	8 (14)[c]	2×10^{-5} (4×10^{-5})[c]
RME	8 (15)[c]	8×10^{-5} (1×10^{-4})[c]

[a]Expected conditions: 0.3 m (1 ft) clean cover over residual contamination.
[b]Minimum-cover: 0.15 m (6 in.) clean soil over residual contamination.
[c]First value represents time=0; parenthetical value is maximum dose/risk over the period of analysis (t=1000 years), if different from time=0.

As shown in Table A-7, estimates of potential doses and excess cancer risks to workers at the properties containing residual contamination are well below the DOE's primary dose limit of 100 mrem/year in all cases, and within the EPA's target risk range. For the expected conditions, the cover depth of 0.3 m (1 ft) makes residual contaminants relatively unaccessible via most exposure pathways; at early times, external gamma radiation and radon emanation are predicted to be the dominant exposure pathways (~82% and ~18%, respectively), while the groundwater ingestion pathway is predicted to also become a significant contributor at distant times (~8%). Under the assumed minimum-cover conditions (i.e., 0.15 m clean soil cover over contaminated zone), external gamma exposure is the dominant exposure pathway (~95%). Again, mean and RME estimates of effective dose equivalent are not significantly different, but mean and RME risk estimates differ primarily due to the difference in exposure duration assumptions.

A.4.3 Intrusion

Potential dose and risk which might result from intrusion into the residual contaminated soil during construction activities at the affected properties was also evaluated. For the commercial/industrial properties, this analysis considered excavation of a perimeter foundation of assumed dimensions 12 m x 18 m x 1.2 m (40 ft x 60 ft x 4 ft), as depicted in Figure 3. Excavated soils were assumed to be spread on the ground surface surrounding the excavation site, with an average depth of approximately 0.05 m (2 in.) over an area of approximately 1000 m^2 (0.25 acre). Since the thickness of the contaminated zone at the commercial/industrial properties is large relative to the depth of excavation, the mixing with uncontaminated soils during excavation will be less than that for the residential properties; for the expected conditions of a 0.3 m (1 ft) cover over the residual contaminated soils, the 4-ft depth of excavation would



Perimeter volume

$2' \times 4' \times 200' = 1600 \text{ ft}^3$

$1/4 \text{ acre} = 10{,}890 \text{ ft}^2$

$$\frac{1{,}600 \text{ ft}^3}{10{,}890 \text{ ft}^2} = 0.147 \text{ ft}$$

= 1.76 inch thick layer to be placed on surface
Say 2 in (0.05 m) thick

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Figure 3. Intrusion Scenario for Commercial/Industrial Properties - Perimeter Foundation Excavation/Redistribution.

include the 1-ft cover layer and the top 3-ft of the contaminated zone. As discussed for the residential basement excavation analysis in Section A.3.3, it is likely that topsoil would be added to support vegetation, but the reduction in dose and risk provided by this clean cover material was not considered in this analysis.

Predicted dose rates and residual risks to an employee at this property are summarized in Table A-8. The predicted dose rate is well below the primary dose limit of 100 mrem/year, and the residual risk estimate is within the EPA's target risk range. External gamma exposure is the dominant exposure pathway (>90%) and the particulate inhalation and radon inhalation pathways provide smaller additional contributions to dose and risk. These estimates are considered to be highly conservative, due to the assumptions of spreading all excavated soils at the ground surface (as opposed to use as subsurface fill in some areas) and the assumed absence of a clean topsoil cover.

Table A-8. Estimated Dose and Risk from Commercial Foundation Excavation Scenario

Receptor Scenario	Effective Dose Equivalent (mrem/year)	Lifetime Excess Cancer Risk
Employee		
Mean	10	3×10^{-5}
RME	10	9×10^{-5}

A.5 Uncertainty Analysis

As noted above, and discussed at greater length in the Baseline Risk Assessment, the exposure assumptions used to predict these potential radiation doses are considered highly conservative. In addition to the parameters addressed in the Baseline Risk Assessment, the characteristics of the residual contaminated zone assumed for this analysis are considered to be very conservative - i.e., a subsurface layer 0.6 to 2 meters thick with soil contaminated at the upper bound of the subsurface residual concentration limit; in reality, such a thick layer of soil homogeneously contaminated at this level is highly unlikely, based on a review of site-specific borehole data and results of previous remedial actions at this and similar sites. Similarly, the assumed lateral extent of the contaminated zone is considered to be conservative; at most properties, residual contamination would be much more localized.

The residual radionuclide concentrations assumed for this analysis are considered to be particularly conservative. As noted in Section A.2, post-remediation characterization data for the 25 vicinity properties already remediated at the Maywood site found residual radionuclide concentrations below 5 pCi/g above background at most sampling locations, with an average of approximately 2 pCi/g above background for thorium-232. Furthermore, based on the available site characterization data, the mean and RME radionuclide concentrations assumed for the evaluation of baseline (pre-remediation) risks in the Baseline Risk Assessment (DOE 1993c)

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were lower than the proposed residual criteria for most properties (i.e., the site-wide upper 95% confidence level soil concentrations are estimated as 4 pCi/g for thorium-232, 0.9 pCi/g for radium-226, and 4 pCi/g for uranium-238). Thus, the source term considered in this analysis of residual risk is highly conservative, and actual dose rates and risks to current and future receptors are expected to be much lower. Similarly, the source term considered for the treated soils to be placed at the MISS, Stepan, and possibly adjacent properties as subsurface fill material is set at the upper bound of the acceptable residual radionuclide concentrations, and treatment to lower residual concentrations is anticipated. Despite this conservatism, doses are not predicted to exceed the 100 mrem/year limit, and lifetime excess cancer risks are estimated at the upper boundary of the target risk range.

The prediction of potential radiation dose and excess cancer risks at distant future times is highly uncertain. For this analysis, a time horizon of 1000 years has been considered, consistent with the provisions in 40 CFR 192 regulations for radium and thorium sites. For several of the exposure scenarios considered in this analysis, larger dose rates and risks may be predicted at future times beyond 1000 years. However, in all cases, the maximum predicted dose rates are below the primary dose limit of 100 mrem/year, and predicted excess cancer risks do not exceed the 10^{-4} level.

Additional verification of the protectiveness of the cleanup criteria for the Maywood site will be provided following completion of the remedial action. Post-remediation site characterization data will be collected by DOE's Independent Verification Contractor to confirm that the cleanup criteria have been achieved. These data will also be used to reevaluate dose rates and potential risks at the site to ensure that human health and the environment will be adequately protected.

For purposes of comparison, radiation exposure from natural sources of radioactivity results in an annual effective dose equivalent of approximately 300 mrem/year (NCRP 1987). The radiation dose associated with potential exposures to residual contaminants at the Maywood site is estimated to be significantly less than that from natural background radiation exposure.

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