SAXTON NUCLEAR EXPERIMENTAL CORPORATION
GENERAL PUBLIC UTILITIES SYSTEM

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March 5, 1992
C301-92-0007
SNEC-92-0008

U. S. Nuclear Regulatory Commission
Att: Document Control Desk
Washington, DC 20555

Gentlemen:

Saxton Nuclear Facility
Operating License No. DPR-4
Docket No. 50-146
Final Release Survey of the
Reactor Support Buildings Report, Revision No. 3

Enclosed for your use is Revision No. 3 to the subject report. This revision was prompted as a result of the February 3, 1992 meeting between SNEC and the NRC. The revision includes discussions about controls that will be in place to prevent intermixing of the concrete rubble with soil and the use of clean fill from offsite to fill void areas among the concrete rubble in the RWDF basement and yard pipe tunnel.

The following changes should be made to your copy of the subject survey report:

1. Remove and replace the binder cover page.
2. Remove and replace the title page.
3. Remove and replace the Executive Summary (pages 1 through 5).
4. Remove and replace Appendix F (pages 674 through 700).
5. Remove and replace Appendix G (pages 701 through 706).
6. Remove and replace Attachment 2, Plan of Action to Disposition the Filled Drum Storage Bunker.

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Please contact us if you require additional information.

Sincerely,

J. E. Hildebrand
President, SNEC

JEH/EP/plp
Attachments

cc: A. Adams - NRC
R. Bores - NRC
M. Reilly - Commonwealth of PA
J. Roth - NRC
S. Weiss - NRC

Saxton Nuclear Experimental Facility

Final Release Survey of the Reactor Support Buildings

Rev. 3 , March 1992

FINAL RELEASE SURVEY REPORT

OF THE

CONTROL AND AUXILIARY BUILDING, RADIOACTIVE WASTE DISPOSAL FACILITY

REFUELING WATER STORAGE TANK, YARD PIPE TUNNEL, AND

FILLED DRUM STORAGE BUNKER

FOR THE

SAXTON NUCLEAR EXPERIMENTAL FACILITY

NRC LICENSE NO. DPR-4

Prepared by GPU Nuclear Corporation for the
Saxton Nuclear Experimental Corporation (SNEC)

Revision 3, March, 1992

EXECUTIVE SUMMARY

The Saxton Nuclear Experimental Facility is a deactivated 20 megawatt thermal (20 MWt) pressurized water reactor (PWR). It is owned by the Saxton Nuclear Experimental Corporation (SNEC) and maintained by GPU Nuclear Corporation (GPUNC). The Saxton reactor facility is maintained under Title 10 Part 50 and Title 10 Part 30 Licenses, and Technical Specifications (Ref. 1). The licenses were amended to possess but not operate the Saxton reactor. The license expires on February 11, 2000 or upon expiration of the SNEC corporate charter, whichever occurs first.

The facility was built from 1960 to 1962 and operated from 1962 to 1972 primarily as a research and training reactor. The fuel was removed from the Containment Vessel (CV) in 1972 and shipped to the Atomic Energy Commission (AEC) facility at Savannah River, S.C. Following fuel removal, equipment, tanks, and piping located outside the CV were removed. The buildings and structures that supported reactor operations were partially decontaminated in 1972 through 1974. The radiological condition of the facility following shutdown was documented in a report titled "Decommissioned Status of the Saxton Reactor Facility" forwarded to the United States Nuclear Regulatory Commission (USNRC) on February 20, 1975 (Ref. 2).

The overall strategy to complete the decommissioning of the facility and to release the site for unrestricted use is a multiyear, multiphased effort. The three principal phases are as follows:

- Removal of groundwater from the basement of the Radioactive Waste Disposal Facility and yard pipe tunnel
- Decontamination, survey, and dismantlement of the reactor support structures or outbuildings

o Decontamination, survey, and dismantlement of the Containment Vessel and restoration of the site

The first phase, groundwater removal, was completed in 1987. The decontamination and survey of the reactor support structures was completed in 1989 and are the subject of this report. The final phase, decommissioning of the Containment Vessel and restoration of the site is expected to be initiated within the next several years. A cost estimate to complete the decommissioning of the Containment Vessel was submitted to the USNRC in July, 1990 (Ref. 3).

A Technical Specification Change Request (TSCR) (Ref. 4) was submitted to the USNRC on September 22, 1987 with Rev. 1 submitted February 25, 1988 (Ref. 5) to remove the reactor support structures/buildings, including the Control and Auxiliary Building (C&A), Radioactive Waste Disposal Facility (RWDF), yard pipe tunnel, Filled Drum Storage Bunker (FDSB), and the Refueling Water Storage Tank (RWST) from Technical Specification Controls as a prerequisite for demolition. This report is being submitted in support of this TSCR. It documents that the reactor support structures/buildings have been decontaminated to USNRC guidelines for unrestricted use.

Decontamination was performed in 1987, 1988, and 1989 on the C&A building, the RWDF building, and the yard pipe tunnel to ensure residual contamination was as low as reasonably achievable. A comprehensive final release survey of these structures/buildings was conducted from October 1988 to June 1989 to verify that residual contamination was within USNRC guidelines for unrestricted use. The RWST was shipped offsite as Low Specific Activity (LSA) radwaste to a contractor for decontamination and final offsite disposal. The tank concrete pad remains onsite and was included in this final release survey. The FDSB is an earthen unit with wooden

cribbing. The top 6 to 12 inches of surficial materials were removed and shipped offsite as LSA radwaste for disposal at a licensed facility. After issuance of the TSCR, the FDSB will be dismantled and the wooden cribbing will be surveyed in accordance with procedures for survey and release of equipment.

The final release survey plan for the reactor support structures was developed based on guidance from NUREG-2082, "Monitoring for Compliance with Decommissioning Termination Survey Criteria" (Ref. 6). The plan incorporated quality assurance (QA) into all phases of the survey process. The survey design involved dividing the building surfaces into 1 square meter grids. Survey measurements in each grid included alpha and beta-gamma count rates, gamma exposure rates, and removable activity. Special surveys of pipes, conduits, holes, expansion joints, and ceiling supports were also conducted. All survey measurements were referenced to survey maps showing the grid locations for each area/cubicle.

Survey results were compared USNRC guidelines for unrestricted use. Surface contaminati measurements were compared to Regulatory Guide 1.86, "Ter nation of Operating Licenses for Nuclear Reactors" (Ref. 7). Additionally, radiation levels were compared to guidelines outlined in References 8, 12, and 13.

Much effort was expended to perform a thorough and accurate survey. Over 11,000 person-hours of Radiological Controls technician time were utilized during the survey. Oversight of the survey was provided by GPUNC supervision and management. Independent surveys were performed by QA personnel. Approximately 5000 one meter-squared grids were surveyed resulting in over 60,000 survey measurements. Special surveys were performed in approximately 1300 grids resulting in at least an additional 8600 survey measurements.

The survey results show that the residual radioactivity is less than the USNRC guidelines for unrestricted use. In fact, decontamination and survey efforts were designed to exceed minimum regulatory guidance and standards whenever lower limits were reasonably achievable. Several areas were identified that were inaccessible during this final release survey. These areas will be surveyed and dispositioned during dismantlement and demolition. Demolition hold points have been identified to allow these additional surveys to occur. The USNRC will be notified of the status of each hold point. If the hold point meets USNRC release guidelines, the USNRC will be given the option to review the survey results before final disposition. If the hold point is determined to be radwaste, it will be disposed of in accordance with procedures for radwaste. Demolition hold points have also been identified for several electrical conduits and pipes that contain residual radioactivity above USNRC guidelines. They will be removed during demolition and disposed of as radwaste even though an evaluation showed they would not be a source of radiation exposure to the public.

Survey documentation is thorough and complete and available for USNRC inspection. All decontamination and survey tasks were accomplished with no adverse effect on the environment or the health and safety of the public and the workers.

Upon issuance of the TSCR by the USNRC, the C&A, RWDF, and FDSB will be dismantled and demolished. The SNEC area fence will remain in place. The concrete rubble from the buildings will be used as backfill in the RWDF basement and the yard pipe tunnel.

An environmental pathways analysis was performed to derive concentration limits for residual radioactivity in the soil which would equate to an annual dose. The standard models used to

calculate the dose require input assumptions and parameters such as a person residing at the site and consuming substantial quantities of food and water taken from the site. This type of scenario is highly unlikely and provides a conservative overestimate of doses that would actually occur.

Soil materials underneath the buildings that will intermix with the concrete rubble were analyzed for residual radioactivity. Based on the conservative dose calculation methodology described, the soil would contribute less than 1 millirem per year to a maximally exposed individual. The soil immediately surrounding the buildings was also sampled and analyzed. Measures will be taken during demolition of the outbuildings to prevent soil that does not satisfy the environmental pathways analysis guidelines from intermixing with the concrete rubble. Clean fill from offsite will be used to fill void areas among the concrete rubble in the RWDF basement and yard pipe tunnel.

A final environmental pathways analysis will be performed at the time of final site closure to ensure that residual radioactivity in materials (soil and concrete rubble) remaining at the site will comply with the dose limit criterion of 10 millirems per year when the site is released for unrestricted use.

APPENDIX F

ENVIRONMENTAL PATHWAYS ANALYSES

INTRODUCTION

An environmental pathways analysis was performed to derive concentration limits for the soil which would equate to an annual dose limit. Federal guidelines for residual radioactivity in soil have not yet been promulgated. In the interim, criteria are developed on a site-specific basis using published environmental dose calculation methodologies. Published data (Ref. 8, 18, and 31) and correspondence from the USNRC to SNEC (Ref. 32) suggests that 10 mrem per year above background is an acceptable dose limit criteria for unrestricted release of the site. A final environmental pathways analysis will be performed at the time of final site closure to ensure that residual radioactivity in materials (soil and concrete rubble) remaining at the site will comply with the dose limit for unrestricted release.

For calculation purposes, a dose of 5 mrem per year from all pathways was used to derive limits on soil radionuclide concentrations. A simple linear multiplication can be used to calculate doses for actual soil sample concentrations because linear chain models were used in the calculations. For example, if 5 mrem/year equates to 5 pCi/gm of Cs-137, then 10 mrem/year equates to 10 pCi/gm Cs-137. For those radionuclides which occur in the environment as a result of prior atmospheric weapon testing, their background concentrations must be added to the derived limit concentrations. For example, appropriate background concentrations for Cs-137 and Sr-90 is 1 pCi/gm (Ref. 33).

The standard models used to calculate the doses require input assumptions and parameters such as a person residing at the site and consuming substantial quantities of food and water taken from the site. This type of scenario is highly unlikely and provides a conservative (overestimate) of doses that would actually occur.

Background

The average person in the United States receives about 300 mrem per year from natural background radiation sources. This includes contributions from cosmic, terrestrial, and internal radiation exposures. Radon gas in the home is the largest component of natural background and is estimated to produce an average annual dose of about 2300 mrem to the lung. This lung dose is considered to be equivalent to a whole body dose of 200 mrem (Ref. 23).

Dose rates from external radiation sources were measured at a number of locations in the vicinity of SNEC using thermoluminescent dosimeters (TLDs). Naturally occurring sources, including radiation of cosmic origin and natural radioactive materials in the air and ground, as well as fallout from prior nuclear weapon testing, resulted in an average of 75 mrem per year being recorded at the monitoring locations. Soil samples collected in the vicinity contain low levels of Cs-137 as a result of prior atmospheric nuclear weapon testing. (See Appendix E for background soil results.) The SNEC soil materials which will be backfilled into the RWDF basement and yard pipe tunnel would contribute a very small additional increment to the normal radiation that people living in the SNEC vicinity already receive from environmental sources.

Exposure Scenarios:

An evaluation of doses to members of the public was performed for three scenarios: 1) abandonment of the site after 30 years and subsequent residential and agricultural use (the intruder scenario), 2) retention of the site with immediate construction of new office space (incidental-occupation scenario), and 3) flooding in the Raystown Branch of the Juniata River scours some soil into the river with subsequent exposure through the fish pathway (flood-fish scenario).

The evaluation of doses was performed for each potential radionuclide of interest in the soil. The dose calculations for the scenarios are complex and include both external exposure due to direct radiation shine from radionuclides in the soil and internal exposure from ingestion and inhalation. Differences in physiology, metabolism, and dietary habits for individual age groups are also considered. The most limiting doses were selected from each pathway for each scenario, that is the age group and critical organ which yield the highest dose. For example, the highest dose for Sr-90 in the milk pathway may be from the infant bone whereas in the groundwater pathway it may be from the teen bone.

Attachment 1 provides a brief description of the dose calculation methodology without decay correction, using exposure of an adult to Co-60 as an example. The methods used are consistent with those given in References 1 to 4 and 14.

Intruder Scenario:

The intruder scenario assumes that the company retains control of the site for 30 years. Since the site is currently used by a Penelec line department, and the site contains an important power grid interconnection, the 30 year estimate for continued site control is reasonable. The Army Corps of Engineers has a flowage easement on the floodplain of the site, and there is a Liberty Township ordinance that prevents building in the floodplain area. The Commonwealth of Pennsylvania also restricts construction in floodplain areas (Ref. 9). These ordinances make residential or office development unlikely.

Despite the low probability of occurrence, an intruder family is assumed to erect a home, grow a garden, drill a well, and tend livestock on the site. The livestock includes at least a milk cow and a beef steer. The pathways evaluated for the resident intruder family are: direct radiation both outside and inside the home, inhalation of resuspended dust both outside and inside the home,

drinking well water, eating homegrown vegetables, drinking raw home-produced cow milk, and eating home-produced beef. Environmental dose assessment methodology is described in Attachment 1.

The direct radiation dose is evaluated for both time spent inside and outside the house. The dose rate outside the house was evaluated by estimating the dose at the center of the top face of a large disk source one foot (30 cm) thick. The dose rate inside the house is based on a more complex geometry. Since the source is the soils surrounding the house, the modeled geometry is a large disk source with a house sized hole in the center. The dose rate at the center of this hole represents the dose rate at the center of the house. Since the actual dose rate will vary from this minimum value at the center, to a larger value at the edge (exterior wall) an adjustment must be made to account for this. Since the dose rate at the edge of a large area source is just one-half of the dose rate at the center, the dose rate at the exterior wall of the house can be assumed to be one-half of the dose rate outside the home. This exterior wall dose and the dose at the center are averaged to obtain an average dose rate for the interior of the house. An additional factor of one-half was then applied to account for the shielding provided by the construction materials of the house. Adults, teenagers, and infants were assumed to spend 12 hours inside the house and two hours outside the house per day. Children were assumed to spend 12 inside and six hours outside per day. The remaining six or 10 hours are assumed to represent time not at home.

The vegetation, cow milk, and meat pathways are treated essentially as presented in Ref. 1. Stable element transfer coefficients are used to estimate the activity in the vegetation. This is then used for the vegetation pathway as well as for feed to the milk and meat animals. One-half of the usage factors in Table E-4 of Ref. 1 (average individual) are used for the consumption rates since this is a more reasonable assumption.

For the inhalation pathway, the radioactivity inhaled depends on the amount of time spent indoors and outdoors at home. The soil is assumed to be resuspended at the rate given in Ref. 2 for the northeast. This value is used to estimate the radioactivity inhaled while outdoors. One-half of this concentration is assumed to be continuously present indoors. Inhalation rates given in Ref. 1 are used and applied to each of the two different concentrations based on the amount of time spent in each location.

The groundwater ingestion pathway requires estimates of the amount of radioactivity in the water as a result of contact with the deep (below 10 feet, near surface soils are above 10 feet) soil. Equilibrium transfer coefficients from References 3 and 4 are used to estimate the concentrations in the water. An annual ingestion quantity of liquids is estimated based on Reference 1 and Reference 5. It was assumed that 33 percent of the total comes from well water at home. This is a reasonable assumption because of the consumption of milk and bottled products. No irrigation of vegetation from well water is assumed. Since the pathway from well water is independent of the surface soil concentrations, different limits have been developed for the deep soil concentrations associated with the groundwater pathway.

The results of the evaluation of the intruder scenario are shown below. These results pertain to this scenario only. Other scenarios may yield more restrictive results. The limits based on the combination of all scenarios are given in the summary. The no decay limit applies to the case where the Company immediately loses control of the site following demolition and backfilling of the site. It is not considered to be a likely scenario and is included only for comparison.

INTRUDER SCENARIO - RADIONUCLIDE CONCENTRATION LIMITS FOR NEAR SURFACE SOILS *

RADIONUCLIDE	LIMIT NO DECAY (pCi/gm)	LIMIT 30 YR. DECAY (pCi/gm)
Co-60	0.56	29
Sr-90	0.17	0.35
Cs-134	0.66	16000
Cs-137	2.1	4.2

* Note: Using assumptions and parameters discussed above, each individual radionuclide concentration in soil will yield a dose of 5 mrem/year.

INTRUDER SCENARIO - RADIONUCLIDE CONCENTRATION LIMITS FOR DEEP SOILS *

RADIONUCLIDE	LIMIT NO DECAY (pCi/gm)	LIMIT 30 YR. DECAY (pCi/gm)
Co-60	1000	53000
Sr-90	0.96	2.0
Cs-134	51	1.2E6
Cs-137	58	120

* Note: Using assumptions and parameters discussed above, each individual radionuclide concentration in soil will yield a dose of 5 mrem/year.

Incidental-Occupation Scenario:

The incidental-occupation scenario assumes that the Company retains control of the site following dismantlement and demolition and installs an office building on the site shortly thereafter. At least one person is assumed to work in the building for the normal 2000 hours per year. The pathways important for this scenario are the groundwater pathway, inhalation pathway, and direct radiation pathway. Since there is no decay associated with this scenario,

the groundwater doses for the incidental-occupation scenario will be the same as those for the intruder scenario except that the individual in this case ingests only one-half as much groundwater from the site as a resident intruder would.

For the direct exposure pathway, no exposure outside the building is considered. The maximum exposed individual therefore spends 2000 hours inside the building exposed to the source outside. This is similar to the indoor portion of the direct exposure pathway in the intruder scenario. In this scenario, only exposure of working-age adults was considered. For the inhalation pathway, the indoor method used in the intruder scenario applies. In this case, the worker was assumed to inhale 33 percent of the total annual air volume while at work, even though 2000 hours is only 25 percent of a year. This is appropriate since breathing rate and volume are expected to be slightly above average during work.

INCIDENTAL-OCCUPATION SCENARIO - RADIONUCLIDE CONCENTRATION LIMITS FOR NEAR SURFACE SOILS *

RADIONUCLIDE	LIMIT (pCi/gm)
Co-60	5.6
Sr-90	1200
Cs-134	6.9
Cs-137	28

* Note: Using assumptions and parameters discussed above, each individual radionuclide concentration in soil will yield a dose of 5 mrem/year.

INCIDENTAL-OCCUPATION SCENARIO - RADIONUCLIDE CONCENTRATION LIMITS FOR DEEP SOILS *

RADIONUCLIDE	LIMIT (pCi/gm)
Co-60	2000
Sr-90	3.1
Cs-134	330
Cs-137	450

* Note: Using assumptions and parameters discussed above, each individual radionuclide concentration in soil will yield a dose of 5 mrem/year.

Flood-Fish Scenario:

In the flood-fish scenario, a flood is assumed to remove the top 10 centimeters of a 100 meter by 100 meter area of the soil and deposit it in a small length of the river bottom. This volume is approximately 1200 metric tons. Following redeposition in the river, 100 percent of the radioactivity in the entire mass of the redeposited soil (sediment) is assumed to be leached from the sediment in one year. This is extremely conservative, since in actuality, deposition of activity into sediments is normal for liquid effluents. Also the surficial material which contains the cesium activity in much of the area has resisted attempts to remove the cesium even by vigorous chemical attack (Ref. 26). For the flood-fish scenario, the derived soil concentrations exceed the criteria listed for the intruder and incidental-occupation scenarios by a factor of 100 to 10,000. The flood-fish pathway, therefore is considered too unrealistic for selecting criteria for the soil. The calculated soil concentrations for the flood-fish scenario are listed below.

FLOOD-FISH SCENARIO - RADIONUCLIDE CONCENTRATION LIMITS FOR NEAR SURFACE SOILS

RADIONUCLIDE	LIMIT (pCi/gm)
Co-60	8.2E4
Sr-90	730
Cs-134	550
Cs-137	750

Summary:

Since the soil concentration limits provided previously are based on a dose limit of 5 mrem/year, rather than on any actual soil, soil will be characterized to determine the actual radionuclide content. Only four radionuclides most likely to be detected above environmental levels have been evaluated.

Following the characterization, the soils which can be used as backfill will be determined based on the concentration limits in this submittal. Soils containing mixtures of radionuclides will be considered to be qualified if the sum of the concentration of each radionuclide divided by its limit does not exceed one (similar to a total MPC calculation, see 10 CFR 20). For example, if radionuclides A, B, and C are present in concentrations Ca, Cb, and Cc, and if the applicable soil limit concentrations are La, Lb, and Lc, respectively, then the concentrations will be limited so that the following relationship exists:

$$(Ca/La) + (Cb/Lb) + (Cc/Lc) \leq 1$$

The radionuclide concentration limits provided are average soil concentration limits. Small area variations above and below these limits can be averaged out provided the averaging area does not cause a failure of one of the assumptions in the evaluation.

The actual soil concentration limit will be the lower of the values derived for each of the three scenarios; the 30 year decay intruder; the no decay incidentally exposed worker; or the flood-fish ingestion. The table below lists the required radionuclide concentration limits selected from each scenario. The concentration limits should be added to the background concentrations.

LIMITS FOR NEAR SURFACE SOILS

RADIONUCLIDE	LIMIT (pCi/gm) (above background)	BASIS (Exposure Pathway-Scenario)
Co-60	5.6	Direct-occupational
Sr-90	0.35	Vegetation-intruder
Cs-134	6.9	Direct-occupational
Cs-137	4.2	Direct-intruder

LIMITS FOR DEEP SOILS*

RADIONUCLIDE	LIMIT (pCi/gm) (above background)	BASIS (Scenario)
Co-60	2000	Occupational
Sr-90	2.0	Intruder
Cs-134	330	Occupational
Cs-137	120	Intruder

* NOTE: Limits for deep soils are based on groundwater pathway.

Conclusions:

Soil materials containing residual radioactivity can remain at the site without any adverse impact on human health and the environment if conducted as described. The standard dose calculation models contain conservative input parameters and assumptions to ensure that the actual dose in any of the scenarios evaluated will not exceed the annual dose limit. Examples of a few of the conservative assumptions are:

1.) The assumption that occupancy actually occurs in a flood plain area that will remain under the control of an electric utility.

2.) The fact that Cs-137 and Co-60 are so strongly bonded to the local surficial materials as to make them chemically unavailable for environmental pathway mobilization and subsequent human uptake.

3.) The assumption that vegetables, milk cows, meat steers, and well water are all produced from the less than 50,000 square feet in question.

4.) Critical organ doses were calculated and applied to the annual dose limit.

5.) The fact that a soil cap will be used and the site revegetated was not included in the calculations.

Given the small doses for the maximally exposed individual, the limited total population, and the small probability of the scenarios, no adverse health effects could reasonably be expected. The limiting concentration for each radionuclide is selected as the lowest from any of the three scenarios evaluated. Since both the intruder scenario and the flood-fish scenario are already actually the worst case accidental exposure conditions and represent the only reasonable unusual circumstances, no additional impacts could be expected from hypothetical accidental exposures.

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ATTACHMENT 1 TO APPENDIX F

DOSE CALCULATION METHODOLOGY

INTRODUCTION

The purpose of this Attachment is to illustrate the methods used to calculate the doses resulting from the various environmental exposure scenarios described earlier. Generally a scenario will result in both external exposure due to direct radiation shine from residual radionuclides in the soil and internal exposure from ingestion of a fraction of the same radionuclides. Since the intention is to calculate doses due to radionuclides which have resulted from operation of the SNEC reactor, dose contributions from naturally occurring radionuclides and from other activities such as atmospheric nuclear weapon testing are not included. Cesium-137 is the only radionuclide routinely found in the soil at the Saxton site which originates from both reactor operations and weapons fallout. Dose calculations will be based upon soil radionuclide concentrations over and above this fallout background increment.

In general terms, the equation for computing a direct radiation dose from residual radionuclides in soil is:

$$D \frac{mrem}{yr} = R_o \cdot t_o + R_i \cdot t_i$$

where $R_o\ t_o$ = product of dose rate outside (mR/hr) times time spent outdoors (hrs/yr)

$R_i\ t_i$ = product of dose rate indoors (mR/hr) times time spent indoors (hrs/yr)

A given scenario may postulate only one or both of the terms in the equation above. Also the assumed values for T_i and T_o will differ from one scenario to another. The indoor and outdoor dose rates

must be calculated from an assumed size and geometric shape of the radiation source, i.e., soil containing residual radioactivity.

A generalized form of the equation for computing the dose from ingestion of radionuclides may be written as:

$$D\ \frac{mrem}{yr} = C_s \cdot T \cdot K \cdot V \cdot U \cdot DCF$$

where C_s = radionuclide concentration in soil, pCi/gm

T = transfer coefficient such as soil to air transfer (resuspension), soil to plant or soil to watertransfer. The units of T will depend on the media involved.

K = bioaccumulation or biological transfer coefficient, which accounts for transfer of ingested radionuclides from food or water to animal flesh or milk. Usually this is a dimensionless number or fraction.

V = mass or volume of food/water ingested annually by an animal. [If a particular pathway does not involve transfer of radionuclides from animal to man, this factor may be set equal to one.]

U = annual usage factor for humans, such as liter/year of water consumed, Kg/year of meat or vegetables consumed or cubic meters per year of air inhaled.

DCF = dose conversion factor in units of mrem/pCi ingested.

Dose conversion factors (DCF) are compiled in the literature. The values used in this analysis were mainly obtained from Ref. 1. Since the absorbed dose depends upon many factors such as energy and type of radiation emitted, organ effected, age of the exposed individual, etc. the DCF's are compiled by radionuclide for each age group and each organ. To perform a complete dose assessment, you must sum the doses from each radionuclide and you must sum over all exposure pathways relevant to a particular scenario. For example, if three radionuclides were present in the soil, and the scenario of interest involved direct exposure, air inhalation and

consumption of water and vegetation (4 exposure pathways), the total dose would be a sum of twelve terms (3 radionuclide doses for each of four pathways). Furthermore this computation is repeated for four age groups (infant, child, teen and adult) to identify the most effected segment of the population.

Given below are the mathematical equations and the parameter values used to calculate the doses for the major exposure pathways.

Groundwater:

Groundwater ingestion dose is derived by estimating the concentration of radionuclide in the water and then applying an annual consumption quantity. This is accomplished by multiplying the concentration of radionuclide in the soil by a soil/water transfer coefficient (Kd) to obtain the water concentration. Usage factors based on reference man and RG 1.109 are used. For example, Reference 3 provides a Kd for cobalt-60 of 1600 ml/g. For a 1 pCi/g soil concentration ([C]) the estimated water concentration ([Cw]) is:

[Cw] = 1000 ml/L * [C] pCi/gm / Kd ml/g
or,
[Cw] = 1000 * 1 / 1600 = 0.6 pCi/L

Appendix F reference 5 gives usage factors for adults derived from ICRP 23. A 1 to 1 to 1 ratio of usage of groundwater, milk, and purchased fluids is assumed for the intruder scenario. For the incidental-occupation scenario it is assumed that 50% of the groundwater an individual ingest is ingested at work. The ratios between the age groups in RG 1.109 are used to define the usage in the other age groups based on the reference man. This results in total usages as listed below:

Adult: 205 L/yr
Child, Teen: 145 L/yr
Infant: 140 L/yr

Annual ingestion quantity is then the annual ingestion volume V times the derived concentration, using the adult and Co-60 as an example:

Q = V L/yr * [Cw]pCi/L
or,
Q = 205 * 0.6 = 123 pCi/yr

The dose to the individual is then the Dose Conversion Factor [DCF] in mrem/pCi times the ingested activity:

D mrem/yr = [DCF] mrem/pCi * Q pCi/yr
or, for adult Co-60
D = 4.02E-5 * 123 = 4.94E-3 mrem/yr for 1 pCi/gm soil for the critical organ

Vegetation:

Vegetation ingestion dose is derived by estimating the concentration of radionuclide in the vegetation and then applying an annual consumption quantity. This is accomplished by multiplying the concentration of radionuclide in the soil by a soil/vegetation transfer coefficient (Biv) (stable element transfer factors) to obtain the vegetation concentration similar to the estimation of groundwater activity. For a 1 pCi/g soil concentration ([C]) the estimated vegetation concentration for cobalt-60 ([Cv]) is:

[Cv] = 1000 g/Kg * Biv(pCi/gm of veg. per pCi/gm soil) * 1 pCi/g
or,
[Cv] = 1000 * 9.4E-3 * 1 = 9.4 pCi/Kg

Usage factors based on Regulatory Guide 1.109 Table E-4 are used. The individual is assumed to obtain 50% of vegetables from the home garden. The annual ingestion amount (M) for an adult is therefore 95 Kg/yr. The annual ingestion activity is then the

concentration in the vegetation times the quantity of vegetation ingested:

Q pCi/yr = M Kg/yr * [Cv] pCi/Kg
or,
Q = 95 * 9.4 = 890 pCi/yr

The dose to the individual is then the Dose Conversion Factor [DCF] in mrem/pCi times the ingested activity:

D mrem/yr = [DCF] mrem/pCi * Q pCi/yr
or, for adult Co-60
D = 4.02E-5 * 890 = 3.58E-2 mrem/yr for 1 pCi/gm soil for the critical organ

<u>Meat</u>:

Meat ingestion dose is derived by estimating the concentration of radionuclide in the meat and then applying an annual consumption quantity and dose conversion factors. This is accomplished by first multiplying the concentration of radionuclide in the vegetation and water by animal consumption rates and transfer coefficients (Fm) to obtain the meat concentration [Cm]. The groundwater [Cw] and vegetation [Cv] concentrations already derived as previously described are used to derive the activity ingested by the steer. Regulatory Guide 1.109 provides animal consumption rates as 50 L/d of water and 50 Kg/d of vegetation.

[Cm] pCi/Kg = [Cw] pCi/L * 50 L/d * Fm d/Kg + [Cv]pCi/Kg * 50 Kg/d * Fm d/Kg
or, for Co-60
[Cm] pCi/Kg = 0.6 pCi/L * 50 L/d * 1.3E-2 d/Kg + 9.4 pCi/Kg * 50 Kg/d * 1.3E-2 d/Kg = 3.4 pCi/Kg

Age dependent consumption rates from RG 1.109 Table E-4 are used.

The individual is assumed to obtain 50% of meat from the home-grown animal. The annual ingestion amount (M) for an adult is therefore 48 Kg/yr. The annual ingestion activity is then the concentration in the meat times the quantity of meat ingested:

Q pCi/yr = M Kg/yr * [Cm] pCi/Kg
or,
Q = 48 * 3.4 = 160 pCi/yr

The dose to the individual is then the Dose Conversion Factor [DCF] in mrem/pCi times the ingested ivity:

D mrem/yr = [DCF] mrem/pCi * Q pCi/yr
or, for adult Co-60
D = 4.02E-5 * 160 = 6.43E-3 mrem/yr for 1 pCi/gm soil for the critical organ

Milk:

Milk ingestion dose is derived in an almost identical manner to meat by estimating the concentration of radionuclide in the milk and then applying an annual consumption quantity and dose conversion factors. This is accomplished by first multiplying the concentration of radionuclide in the vegetation and water by animal consumption rates and transfer coefficients (Fl) to obtain the milk concentration [Cl]. The groundwater [Cw] and vegetation [Cv] concentrations already derived as previously described are used to derive the activity ingested by the milk cow. Regulatory Guide 1.109 provides animal consumption rates as 60 L/d of water and 50 Kg/d of vegetation.

[Cl] pCi/L = [Cw] pCi/L * 60 L/d * Fl d/L + [Cv] pCi/Kg * 50 Kg/d * Fl d/L
or, for Co-60
[Cl] pCi/Kg = 0.6 pCi/L * 60L/d * 1.0E-3 d/L + 9.4 pCi/Kg * 50 Kg/d* 1.0E-3 d/L = 0.27 pCi/L

As described in the section describing groundwater, Regulatory Guide 1.109 and reference man data are used to estimate the amount of milk ingested, assuming that 33% of all fluids ingested by the individual is milk and that all the milk ingested is produced at home. The annual ingestion amount (M) for an adult is therefore 205 L/yr. The annual ingestion activity is then the concentration in the milk times the quantity of milk ingested:

Q pCi/yr = M L/yr * [Ci] pCi/L
or,
Q = 205 * 0.27 = 55 pCi/yr

The dose to the individual is then the Dose Conversion Factor [DCF] in mrem/pCi times the ingested activity:

D mrem/yr = [DCF] mrem/pCi * Q pCi/yr
or, for adult Co-60
D = 4.02E-5 * 55 = 2.21E-3 mrem/yr for 1 pCi/gm soil for the critical organ

Inhalation:

Dose due to inhalation of resuspended particulates is estimated by deriving an average air concentration multiplying by the age dependent inhalation rates and a Dose Conversion Factor. This is accomplished by first estimating the resuspension of the soil. Reference 2 provides guidance that in the northeast an average airborne dust loading is about 0.258 mg/cubic meter (m^3). At a 1 pCi/g soil activity, the air concentration is then the soil activity times the air dust loading:

[Cao] = (1 pCi/g / 1000 mg/g) * 0.258 mg/m^3 = 2.58E-4 pCi/m^3

It is also assumed that the radionuclide air concentration inside a building (the home for the intruder or the office building for

the incidental-occupation scenarios) is one-half that outdoors as calculated above or:

$[Cai] = 1.29E-4\ pCi/m^3$

Age dependent inhalation rates are give in Table E-5 of Reference 1. These total annual inhalation volumes (A m^3/yr) are adjusted for the amount of time each age group is assumed to spend indoors (Ti hrs) at the site, outdoors at the site (To hrs), and not at the site. For example, the adult is assumed to spend 12 hours inside, 2 hours outside, and 10 hours not at home for the intruder. For the incidental-occupation scenario, the individual is assumed to inhale 33% of the total annual volume at work even though the normal 2000 hours at work is only 25% of the time. For example, the annual air volumes (Vi m^3 and Vo m^3) for an adult at the site are:

$Vi\ m^3/yr = Ti\ hrs/d\ /\ 24\ hrs/d * A\ m^3/yr$

or,

$Vi = 12\ hrs/d\ /\ 24\ hrs/d * 8000\ m^3/yr = 4000\ m^3/yr$

$Vo\ m^3/yr = To\ hrs/d\ /\ 24\ hrs/d * A\ m^3/yr$

or,

$Vo = 2\ hrs/d\ /\ 24\ hrs/d * 8000\ m^3/yr = 670\ m^3/yr$

The activity (A) inhaled each year is then the volume inside times the air concentration inside plus the volume outside times the air concentration outside:

$A\ pCi/yr = Vo\ m^3 * [Cao]\ pCi/m^3 + Vi\ m^3 * [Cai]\ pCi/m^3$

or,

$A = 670 * 2.58E-4 + 4000 * 1.29E-4 = 0.69\ pCi/yr$

These total annual inhaled activities can then be multiplied by the inhalation dose conversion factor to obtain annual dose:

$D\ mrem/yr = A\ pCi/yr * DCF\ mrem/pCi$

For the adult and cobalt-60 this would be:

D = 0.69 * 7.46E-4 = 5.15E-4 mrem/yr

Direct Radiation:

Dose from direct radiation is estimated using the methodology in Reference 13. The source is assumed to be a 100-meter-diameter, 30-centimeter-thick cylinder of soil. An air shield 45 centimeters thick is used and the dose rate is evaluated at knee height.

The same times spent at the site indoors and outdoors, as described in the section on inhalation doses, are used for the direct radiation doses. The dose rate outside is equivalent to that calculated from the 100 m diameter source (Do). The dose rate inside (Di) is derived by calculating a second dose rate using a 13-meter-diameter source to represent the area of a building. This result (Db) is subtracted from the larger source dose rate to provide a dose representative of the center of an area inside the larger source that itself is not a source, i.e., a "no-source hole".

Since an individual in a building can be expected to move about, the average inside dose rate then would be the average of the dose at the center of the building and the dose rate at the edge. The dose rate at the edge of the "no-source hole" is taken as one-half of the dose rate in the center of the large source, since this is a simple 2 pi to 1 pi geometry change.

A reduction of this average of one-half is then taken to account for the shielding effect of building materials:

Di mrem/hr = (((Do - Db) + (Do / 2)) / 2) /2

For Co-60 the outside dose rate (Do) for 1 pCi/g soil is 3.2E-3 mR/hr
For Co-60 the building center dose rate (Db) for 1 pCi/g soil is 3.0E-3 mR/hr.

The inside dose rate is therefore:

$$Di = (((3.2E{-3} - 3.0E{-3}) + (3.2E{-3} / 2)) / 2) / 2 = 4.5E{-4} \text{ mR/hr}$$

Dose to the individual (D) is then the inside dose rate times the time spent indoors plus the outside dose rate times the time spent outdoors. For example, as detailed in the inhalation section, an adult is assumed to spend two hours per day outside and 12 hours per day inside:

$$D \text{ mrem/yr} = (Do \text{ mR/hr} * 2 \text{ hrs/d} + Di \text{ mR/hr} * 12 \text{ hrs/d}) * 365 \text{ d/yr}$$

or,

$$D = (3.2E{-3} * 2 + 4.5E{-4} * 12) * 365 = 4.3 \text{ mR/yr}$$

which is assumed to be equivalent to 4.3 mrem/yr.

Flood-Fish:

The dose from the flood-fish pathway is evaluated by assuming a portion of the surface soils is flushed into the river by a flood. It is assumed that an area of 100 meters by 100 meters and 10 cm deep is removed and deposited in the river. This is a volume of 1.0E9 cubic centimeters (cc). Using a density of 1.2 grams per cc this is then a mass of 1.2E9 grams, or at 1 pCi/gm, a total of 1.2E9 pCi.

The Raystown Branch of the Juniata River has an annual flow of 918 cubic feet per second which is equivalent to 8.2E11 L/yr. Assuming that all of the activity in the redeposited soils is leached out of the soils into the river water in one year, this would result in

concentrations in the river water [Cr]:

[Cr] pCi/L = 1.2E9 pCi / 8.2E11 L = 1.5E-3 pCi/L

The concentrations of radioactive materials in the fish can then be estimated by applying bioaccumulation factors given in Reference 1. For example, the factor (Bf) for cobalt-60 is 50 pCi/Kg in fish per pCi/L in the water. The concentration in the fish [Cf] is therefore:

[Cf] = Bf (pCi/Kg)/(pCi/L) * [Cr] pCi/L
or,
[Cf] = 50 * 1.5E-3 = 0.075 pCi/Kg

The amount of radioactivity an individual would ingest is then this concentration in fish times the annual amount of fish a person would consume. Reference 1 provides age dependent annual ingestion quantities. For example, adults are expected to eat as much as 21 Kg of freshwater fish each year. The total dose is then the concentration in the fish times the annual ingestion times the dose conversion factor for one year:

D = [Cf] pCi/Kg * 21 Kg * DCF mrem/pCi
or,
D = 0.075 * 21 * 4.02E-5 = 6.3E-5 mrem/yr for 1 pCi/g cobalt-60 in the soil.

APPENDIX G

DISMANTLEMENT AND DEMOLITION PROCESS

DISMANTLEMENT AND DEMOLITION PROCESS

Upon issuance by the USNRC of the TSCR to remove the C&A, RWDF, FDSB, and RWST pad from Technical Specification controls, each of the structures will be readied for dismantlement. It is SNEC's intent to restore the land to its original contour such that it will have no impact upon the U.S. Army Corps of Engineers' flowage easement. There will be no regulated demolition landfill created.

Masonry material from the demolition of structures to 3 feet below grade will be used as backfill in the RWDF basement and the yard pipe tunnel. The backfilled RWDF basement and yard pipe tunnel will be covered with a soil cap. Construction rebar and other non-masonry materials will be removed to the extent possible from the concrete prior to its use as backfill material. Other non-masonry materials from the buildings such as glass and roofing, will be removed to the extent possible. Excess concrete rubble that can not be used as backfill and other non-masonry materials will be disposed of offsite in an approved landfill or recycled.

The filled drum storage bunker is an earthen unit with wooden cribbing. The interior wall consisting of the wood cribbing will be surveyed in accordance with procedures for release of equipment. If the wood cribbing meets USNRC guidelines for release it will be disposed of offsite in an approved landfill.

All applicable dismantlement and demolition permits will be secured prior to the start of work. Demolition work will be conducted in a manner to minimize any environmental impact.

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Appropriate radiological and environmental controls will be in place throughout the dismantlement and demolition process. Several areas were identified during the final release survey that were inaccessible to survey instruments. These areas will be surveyed and dispositioned during dismantlement and demolition. Demolition hold points have been identified to allow these additional surveys to occur. The USNRC will be notified of the status of each hold point after each has been surveyed. If the hold point meets USNRC release guidelines, the USNRC will be given the option to review the results before final disposition. If the hold point is considered to be radwaste, it will be disposed of in accordance with procedures for radwaste. These hold points include:

- o walls behind the electrical breaker boxes and emergency lighting fixtures (C&A and RWDF)
- o structural I-beams in C&A
- o drain pipes off of the C&A roof
- o floors underneath groundwater collection containers (RWDF)
- o ceiling hatch in the RWDF Evap. Room
- o area underneath wooden frame "bridge" in the C&A pipe tunnel
- o area underneath groundwater collection pipes in the RWDF pipe tunnel
- o two pipes in RWDF Pump and Compressor Room ceiling
- o two pipes in RWDF Drum Shipping Room
- o areas underneath any wooden supports
- o several penetrations in Yard Pipe Tunnel ceiling

Radiological Controls technicians will provide job coverage throughout the dismantlement and demolition process. They will be instructed to survey the hold points identified above as well as any additional areas not previously surveyed that may become accessible. If any areas/materials exceed the USNRC release

guidelines, they will either be decontaminated to satisfy release criteria or dispositioned offsite as radwaste.

Special surveys identified several penetrations and areas that were not decontaminated to below USNRC release guidelines. They also have been designated as demolition hold points. They will be removed during demolition to ensure residual contamination is as low as reasonably achievable. These hold points include:

- structural I-beams in C&A Auxiliary Equipment Room
- 2 drain pipes in the floor of the C&A Toilet and Shower Room
- pipe in chlorinator/sewage treatment building
- 9 pipes in the RWDF building and yard pipe tunnel
- 22 electrical conduits located underneath the concrete floors in the C&A Switchgear and Variable Frequency Rooms
- drain pipe in floor of C&A Auxiliary Equipment Room

Excess structural materials that can not be used as backfill, will be disposed of offsite. This material will receive additional monitoring prior to release from the site.

To provide assurance that these precautions and requirements are met, a staff of Radiological Controls technicians will be maintained at the site during demolition. This staff will be supervised by a TMI qualified Group Radiological Controls Supervisor (GRCS) or the Saxton Radiation Safety Officer (RSO).

The soil underneath the buildings has been sampled and analyzed and found to be consistent with the environmental pathways analysis and the NRC guidelines provided in the Oak Ridge Associated University Confirmatory Survey Report. The soil immediately surrounding the buildings was also sampled and analyzed. Measures will be taken

during demolition to prevent soil that does not satisfy the environmental pathways analysis guidelines from intermixing with the concrete rubble. Clean fill from offsite will be used to fill void areas among the concrete rubble in the RWDF basement and yard pipe tunnel.

Appropriate environmental monitoring will continue to be performed during the demolition process.

ATTACHMENT 2

PLAN OF ACTION TO DISPOSITION THE
FILLED DRUM STORAGE BUNKER

PLAN OF ACTION TO DISPOSITION THE FILLED DRUM STORAGE BUNKER

The FDSB is a timber and earthen structure that was used as temporary storage for low level radwaste during plant operations. The structure consists of four walls and a floor. The internal walls are composed of timbers arranged in matrices intertwined with soil. The top 6 to 12 inches of surficial materials were removed from the outside walls leaving 2 to 4 feet of clay soil.

The drums of soil and pile of soil that were being stored inside the bunker were removed to gain access to the bunker and the macadam floor. The soil was relocated to the north side of the SNEC area fence and was stabilized to prevent erosion and sedimentation problems. The macadam floor of the bunker was surveyed using a gamma scintillation detector with a ratemeter. Measurements greater than 2 times background levels were excavated and will be dispositioned appropriately.

The outside walls were gridded (3 meters x 3 meters) and soil samples were collected and analyzed from each grid. Soil core samples (2 to 4 feet) were taken from the inside and outside walls. Samples were also taken of the soil that became exposed after excavation of contaminated sections of the macadam floor. Figure 1 shows the sample locations and Tables 1, 2, and 3 contain the radiological results of the grids, soil cores, and soil floor, respectively.

Following approval of Tech. Spec. Change Request No. 53, the FDSB will be dismantled by a demolition contractor. The timbers will be dismantled and separated from the soil. They will be surveyed in accordance with procedures for survey and release of equipment and materials for unrestricted use. The release criteria will be consistent with the NRC IE Information Notices 81-07 and 85-92. Any timbers found to be greater than the release criteria will either be decontaminated and resurveyed or disposed of as low level radwaste. The timbers will be staged onsite and the USNRC will be notified of their status. The USNRC has the option to review the results and/or conduct verification surveys before final disposition. After final approved release, the timbers may be recycled or disposed of offsite in an approved landfill.

The soil component of the bunker will remain onsite and stabilized to prevent erosion and sedimentation problems. The macadam floor will also remain onsite. Final release of the soil and macadam floor will be addressed at the time of final site closure.

FIGURE 1

FILLED DRUM STORAGE BUNKER (FDSB)

(Layout of Grids and Sample Locations)

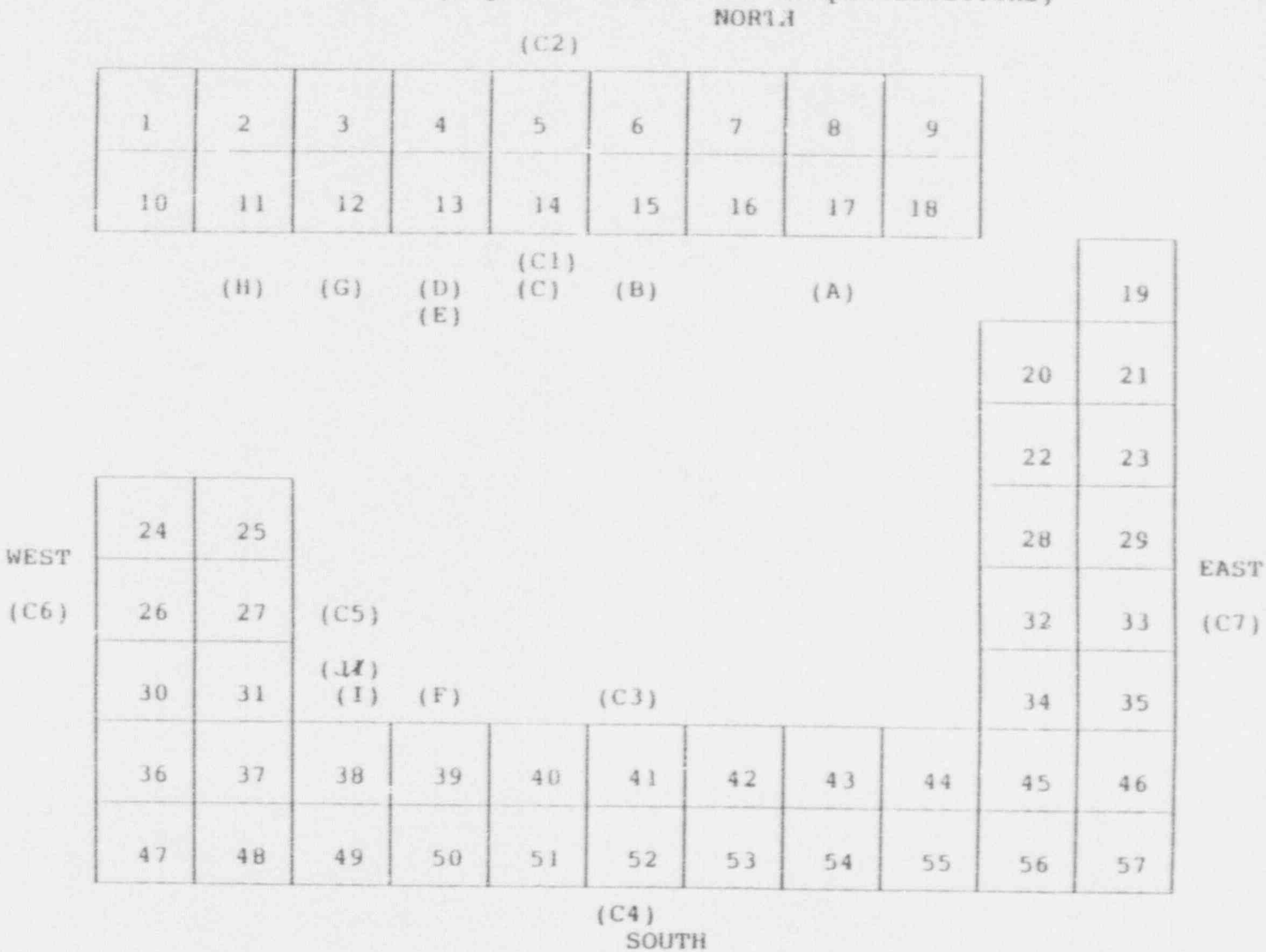

TABLE 1

SOIL RESULTS FROM FDSB OUTSIDE WALL GRIDS

Cs-137 pCi/gm

Grid No.	Cs-137 pCi/gm	Grid No.	Cs-137 pCi/gm	Grid No.	Cs-137 pCi/gm
1	1.7 ± 0.2	20	0.73 ± 0.07	39	2.5 ± 0.2
2	71.0 ± 7	21	0.92 ± 0.09	40	2.6 ± 0.3
3	5.3 ± 0.5	22	8.0 ± 0.8	41	5.6 ± 0.6
4	1.2 ± 0.1	23	2.4 ± 0.2	42	13.0 ± 1
5	0.55 ± 0.07	24	3.0 ± 0.3	43	2.3 ± 0.2
6	0.98 ± 0.1	25	0.50 ± 0.06	44	0.79 ± 0.08
7	0.49 ± 0.06	26	1.3 ± 0.1	45	0.34 ± 0.06
8	5.5 ± 0.5	27	17.0 ± 2	46	0.31 ± 0.05
9	5.6 ± 0.6	28	1.4 ± 0.1	47	3.1 ± 0.3
10	0.09 ± 0.029	29	1.1 ± 0.1	48	2.6 ± 0.3
11	1.4 ± 0.1	30	7.5 ± 0.8	49	1.5 ± 0.2
12	0.91 ± 0.09	31	5.8 ± 0.6	50	0.82 ± 0.08
13	0.56 ± 0.06	32	0.78 ± 0.08	51	1.2 ± 0.1
14	0.26 ± 0.04	33	3.1 ± 0.3	52	2.7 ± 0.3
15	0.29 ± 0.05	34	2.4 ± 0.2	53	1.5 ± 0.1
16	0.44 ± 0.05	35	1.8 ± 0.2	54	2.1 ± 0.2
17	0.97 ± 0.01	36	7.0 ± 0.7	55	2.1 ± 0.2
18	0.76 ± 0.08	37	18.0 ± 2	56	5.1 ± 0.5
19	6.8 ± 0.7	38	9.9 ± 1	57	2.7 ± 0.3

TABLE 1 (Cont'd)

SOIL RESULTS FROM FDSB OUTSIDE WALL GRIDS

Co-60 pCi/gm

Grid No.	Co-60 pCi/gm
2	0.51 $\pm$ 0.08
35	0.18 $\pm$ 0.04
38	1.2 $\pm$ 0.05
42	0.16 $\pm$ 0.05
43	0.12 $\pm$ 0.05

TABLE 2

RESULTS OF SOIL CORES FROM INSIDE AND OUTSIDE WALLS OF THE FDSB

CORE I.D.	Cs-137 pCi/gm
C1 (inside wall)	0.26 ± 0.05
C2 (outside wall)	<0.04
C3 (inside wall)	2.6 ± 0.3
C4 (outside wall)	<0.07
C5 (inside wall)	2.9 ± 0.3
C6 (outside wall)	0.33 ± 0.06
C7 (outside wall)	<0.05

TABLE 3

RESULTS OF SOIL SAMPLES FROM EXCAVATED HOLES IN THE FDSB FLOOR

SOIL NO.	Cs-137 pCi/gm
A	0.92 ± 0.09
B	0.22 ± 0.06
C	4.8 ± 0.5
D	0.49 ± 0.05
E	0.043 ± 0.029
F	1.8 ± 0.2
G	2.8 ± 0.3
H	7.9 ± 0.8
I	2.1 ± 0.2
J	5.0 ± 0.5