Pennsylvania Department of Environmental Protection
Rachel Carson State Office Building
P.O. Box 8469
Harrisburg, PA 17105-8469
March 9, 2006

Bureau of Radiation Protection

717-787-2480
Fax: 717-783-8965

J-7

Mr. Jim Kottan
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

03029288

Re: License Number 37-17860-02, Quehanna Decommissioning Project Decommissioning Plan

Dear Mr. Kottan:

The Commonwealth of Pennsylvania Department of Environmental Protection (PADEP) has been working with our decommissioning operations contractor to develop a revised decommissioning plan (D-Plan). The development of this new D-Plan was deemed to be necessary after the discovery of contamination above our release criteria by NRC's confirmatory contractor, Oak Ridge Institute for Science and Education, in May 2005. Most of the contamination was later determined to be volumetric within some areas of concrete. Our current release criteria are from Regulatory Guide 1.86, and it is valid only for surface contamination. These criteria were originally chosen when it was thought the facility was to be decontaminated and reused for industrial purposes by an existing tenant. Subsequently, the tenant declared bankruptcy and vacated the site. The intention is to now raze all above ground structures and to return the site to its natural state as a designated "Wild Area". As a result, the decision was made to change the release criteria to comply with current regulations and guidance (10 CFR 20 Subpart E and NUREG 1757).

Please find enclosed three copies of the new D-Plan for NRC review. The D-Plan details the proposed release criteria for the entire site. Please feel free to call Bryan Werner of my staff at (717) 787-2781 if you have any questions.

Sincerely,

Robert C. Maiers

Robert C. Maiers, P.E.
Chief, Decommissioning and Surveillance Division
Bureau of Radiation Protection

FULL COST RECOVERY ACTION

TAC NO. U01703

Enclosure: Decommissioning Plan For The Quehanna, Pennsylvania Site (3 copies)

cc: A. Thomas, DCNR, w/o enclosure
B. Werner, BRP, w/o enclosure

138549

ENERGYSOLUTIONS

Document Number 82A9089
Revision 4

DECOMMISSIONING PLAN FOR THE QUEHANNA, PENNSYLVANIA SITE

37-17860-02
03029288

March 2006

Prepared for:
Commonwealth of Pennsylvania
Department of Environmental Protection
Bureau of Radiation Protection
P.O. Box 8469
Harrisburg, PA 17105-8469

Prepared by:

Energy*Solutions*, LLC
143 West Street
New Milford CT, 06776

CONTROLLED COPY No. 640

138549

DECOMMISSIONING PLAN
FOR THE QUEHANNA, PENNSYLVANIA SITE

SIGNATURE PAGE

Project Manager:
Lee G. Penney _____ Date: 3/6/06

Operations Manager:
Lee G. Penney _____ Date: 3/6/06

Field Services RSO:
Kenneth Kasper, CHP _____ Date: 3/6/06

REVISION LOG

Revision Number	Affected Pages	CRA Number	Approval
1	All	9962	L. Penney
2	All	11199	L. Penney
3	1-1,1-8, 2-1, 3-10, 4-15, 6-3, 6-4, 8-2, 8-3, 8-6, 9-3	11274	L. Penney
4	All	11793	K. Kasper

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ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

ACM	asbestos-containing material
AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
ANSI/ANS	American National Standards Institute/American Nuclear Society
BMP	best management practice
BRP	Bureau of Radiation Protection (Pennsylvania)
Canberra	Canberra Industries, Inc.
CFS	cubic feet per second
Ci	curies
Commonwealth	Commonwealth of Pennsylvania
CRA	change request authorization
D&D	decontamination and decommissioning
DCGL	derived concentration guideline levels
DCNR	Department of Conservation and Natural Resources (Pennsylvania)
DOC	Decommissioning Operations Contractor
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FSS	Final Status Survey
FSRSO	Field Services Radiation Safety Officer
HAZWOPER	Hazardous Waste Operations and Emergency Response
LLRW	low-level radioactive waste
LTR	License Termination Rule (10 CFR 20, Subpart E)
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	maximum contaminant level
mg/l	milligrams per liter
mph	miles per hour
MMA	methylmethacrylate
mrad/hr	millirad per hour
mrem/yr	millirem per year
NES	NES, Inc.
NRC	U.S. Nuclear Regulatory Commission
NUREG	NRC Regulatory Guidance
OSHA	U.S. Occupation Safety and Health Administration
PADEP	Pennsylvania Department of Environmental Protection
pCi/L	picocuries per liter
pCi/g	picocuries per gram
Penn State	Pennsylvania State University
PermaGrain	PermaGrain Products, Inc.
PNDI	Pennsylvania Natural Diversity Inventory
QA	quality assurance
QAPP	Quality Assurance Project Plan
rad/hr	rad per hour
RCA	radiological control area
RSO	Radiation Safety Officer
RWP	radiation work permit

ACRONYMS AND ABBREVIATIONS
(Continued)

SNAP-7	Systems for Nuclear Auxiliary Power
$Sr(NO_3)_2$	strontium nitrate
$SrTiO_3$	strontium titinate
SRSO	Site Radiation Safety Officer
SSHASP	Site-Specific Health and Safety Plan
UST	underground storage tank
WWTB	Waste Water Treatment Building
yd^3	cubic yard

1.0 INTRODUCTION

1.1 LICENSE INFORMATION

This Decommissioning Plan describes the plans for terminating U.S. Nuclear Regulatory Commission (NRC) Radioactive Materials License Number 37-17860-02 formerly held by PermaGrain Products, Incorporated (PermaGrain) of Newton Square, Pennsylvania and currently held by the Pennsylvania Department of Environmental Protection (PADEP). The PADEP took over the license following PermaGrain filing Chapter 7 bankruptcy in December 2002. The license covers residual radioactive material and contamination that are present at the manufacturing facility as a result of research, development, and production operations conducted by parties under contract to the former U.S. Atomic Energy Commission (AEC). The facility, commonly referred to as the Quehanna Site, is owned by the Department of Conservation and Natural Resources (DCNR) and is located near Karthaus, Pennsylvania.

The current NRC license, dated September 29, 2003, includes Revision 3 of this Decommissioning Plan. The current license will expire March 31, 2008. This Decommissioning Plan, Revision 4, will subsequently become an amendment to the renewed license.

1.2 SITE DESCRIPTION

The Quehanna facility is located at 115 Reactor Road, Karthaus, Clearfield County, Pennsylvania. The site is approximately 21 miles northeast of Clearfield, Pennsylvania at approximately 41° 13' north latitude and 78° 14' west longitude. The site, identified in Figure 1-1, is located in the Quehanna Wild Area of the Moshannon State Forest. The area is heavily wooded and sparsely populated.

The Quehanna Site includes or included many affected structures and systems, such as the hot cells complex, the Waste Water Treatment Building (WWTB) with associated underground tanks and piping, the Reactor Bay, and the hot cell ventilation system. Some of these have been removed as clean debris or partially decontaminated and disposed of radioactive waste. The facility also includes other laboratories, production and storage areas, and offices formerly used by PermaGrain. On-site radioactive material consisted of fixed and removable strontium-90 contamination and discrete cobalt-60 sources. The layout of the facility is shown in Figures 1-2 through 1-4.

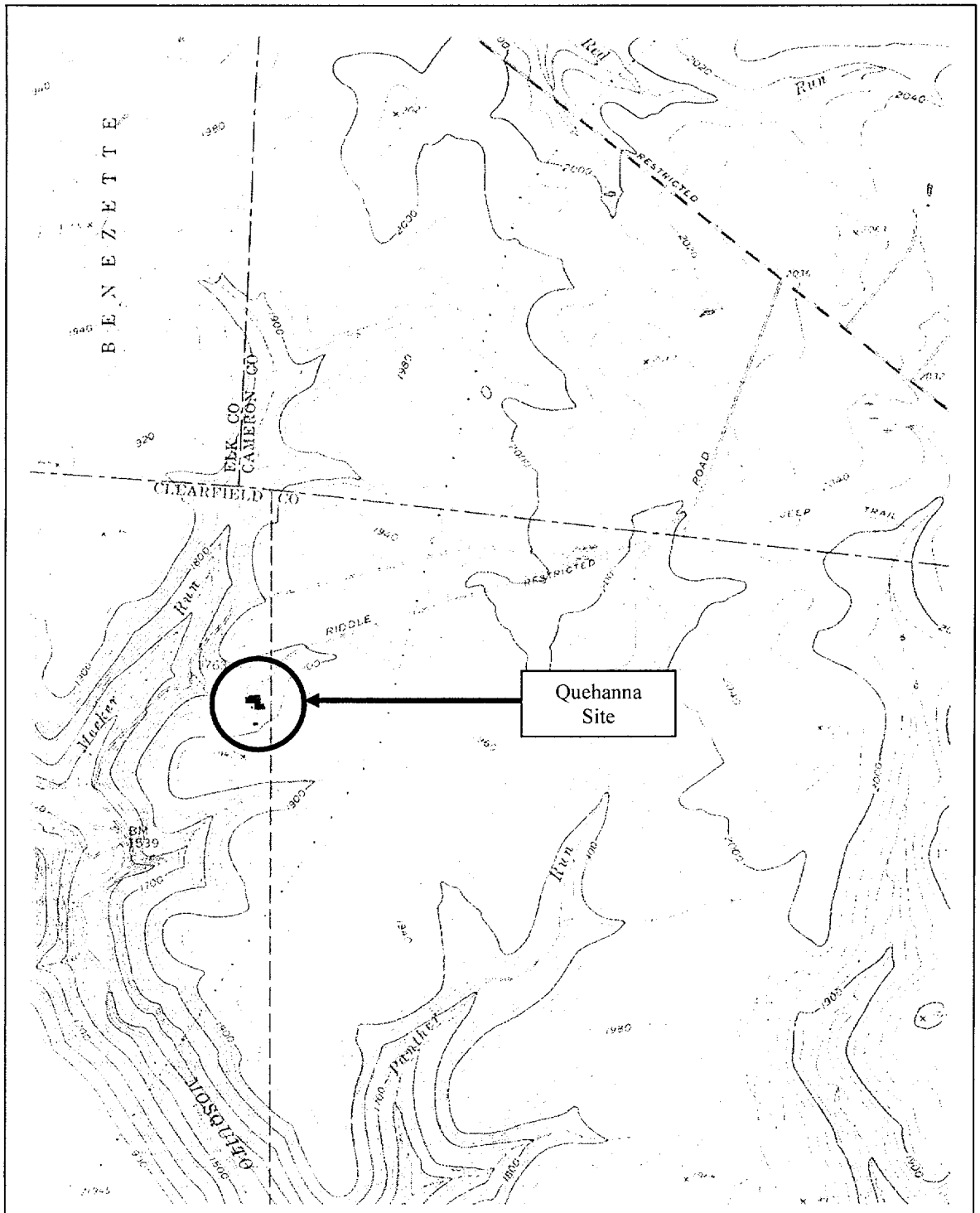
1.3 SUMMARY OF LICENSED ACTIVITIES

The 50,000-acre Quehanna Wild Area was originally state forest land that was transferred to the Curtiss-Wright Corporation by the Pennsylvania Bureau of Forestry for jet engine and nuclear research in 1955. In 1957, the AEC issued a license to Curtiss-Wright to operate a swimming pool-type research reactor at the Quehanna facility. The facility license also included the use of hot cells, laboratories, and support features. Licensed isotopic activities began in 1958. In 1960, Curtiss-Wright donated the facility to Pennsylvania State University (Penn State) who, in turn, leased the hot cells to the Martin Marietta Corporation. Beginning in July 1962, Martin Marietta used the hot cells to manufacture several prototype thermoelectric generators under contract to the AEC.

Martin Marietta's possession license allowed them to maintain megacurie amounts of high-specific activity strontium-90.

Martin Marietta terminated its lease with Penn State in 1967 and vacated the facility after partially decontaminating portions of the facility and Penn State released its interest in the Quehanna facility back to the Commonwealth of Pennsylvania (Commonwealth). The Commonwealth then leased the facility to NUMEC, a subsidiary of the Atlantic-Richfield Corporation. NUMEC managed a large irradiator containing in excess of 1 million curies of cobalt-60 for projects involving food irradiation, sterilization, irradiation of polymer-impregnated hardwood and other applications of intense gamma radiation in the reactor pool, which once contained a test reactor. Atlantic-Richfield used the hot cells for activities involving irradiated mixed oxide fuel. In 1978, a group of Atlantic-Richfield employees bought the wood irradiation process, including the cobalt pool irradiator and related equipment at the Quehanna facility and formed PermaGrain.

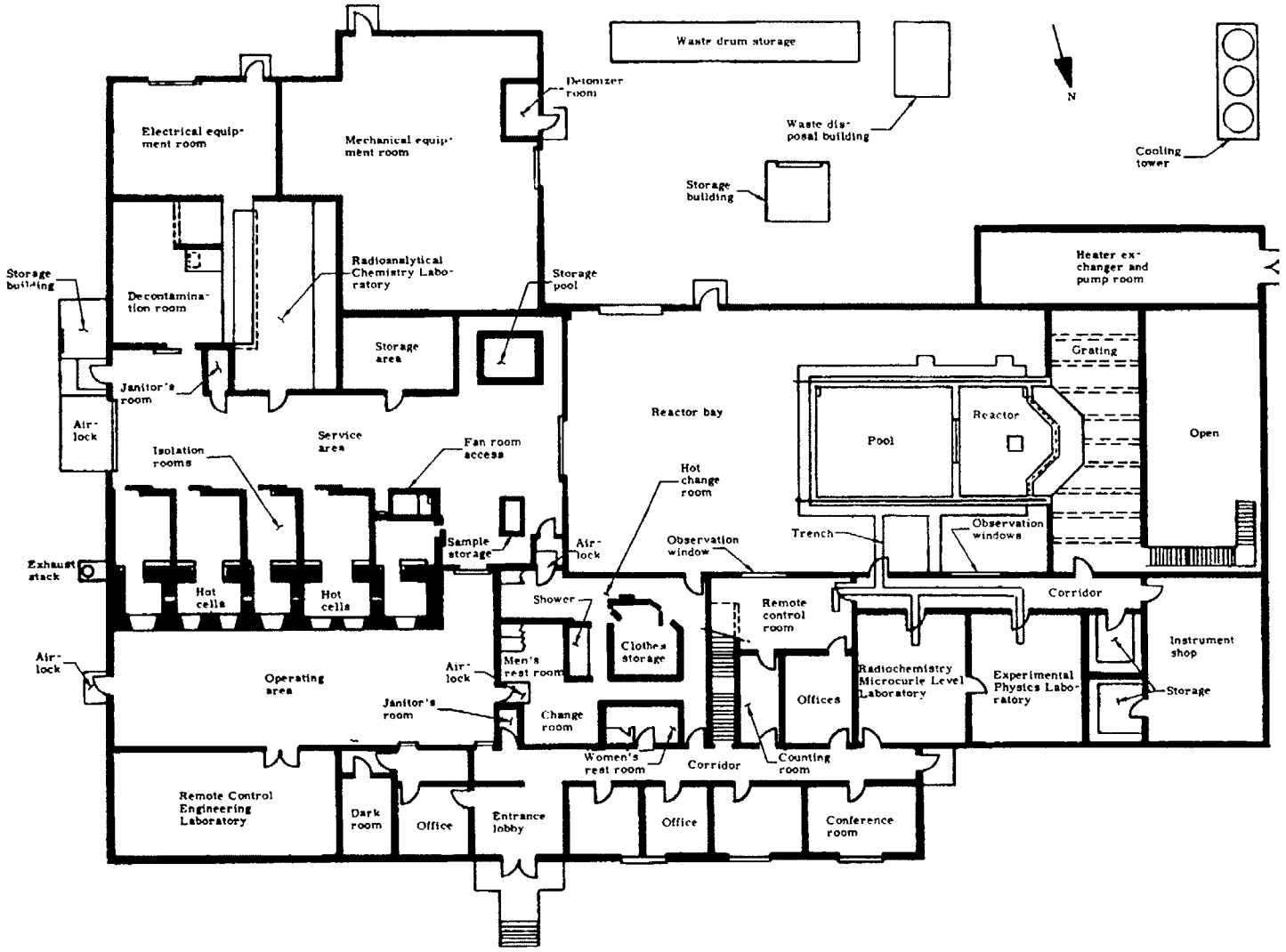
The current NRC License Number 37-17860-02 was initiated by PermaGrain in July 1998 and covers the residual contamination and radioactive materials from the AEC-contracted and other operations. The license allows for an unspecified amount of any byproduct or special nuclear material including strontium-90 and cobalt-60. The PADEP became the official licensee in December 2002 following PermaGrain's filing for Chapter 7 bankruptcy.



Source: U.S. Geological Survey
Devils Elbow, PA, Quadrangle
Photorevised 1971

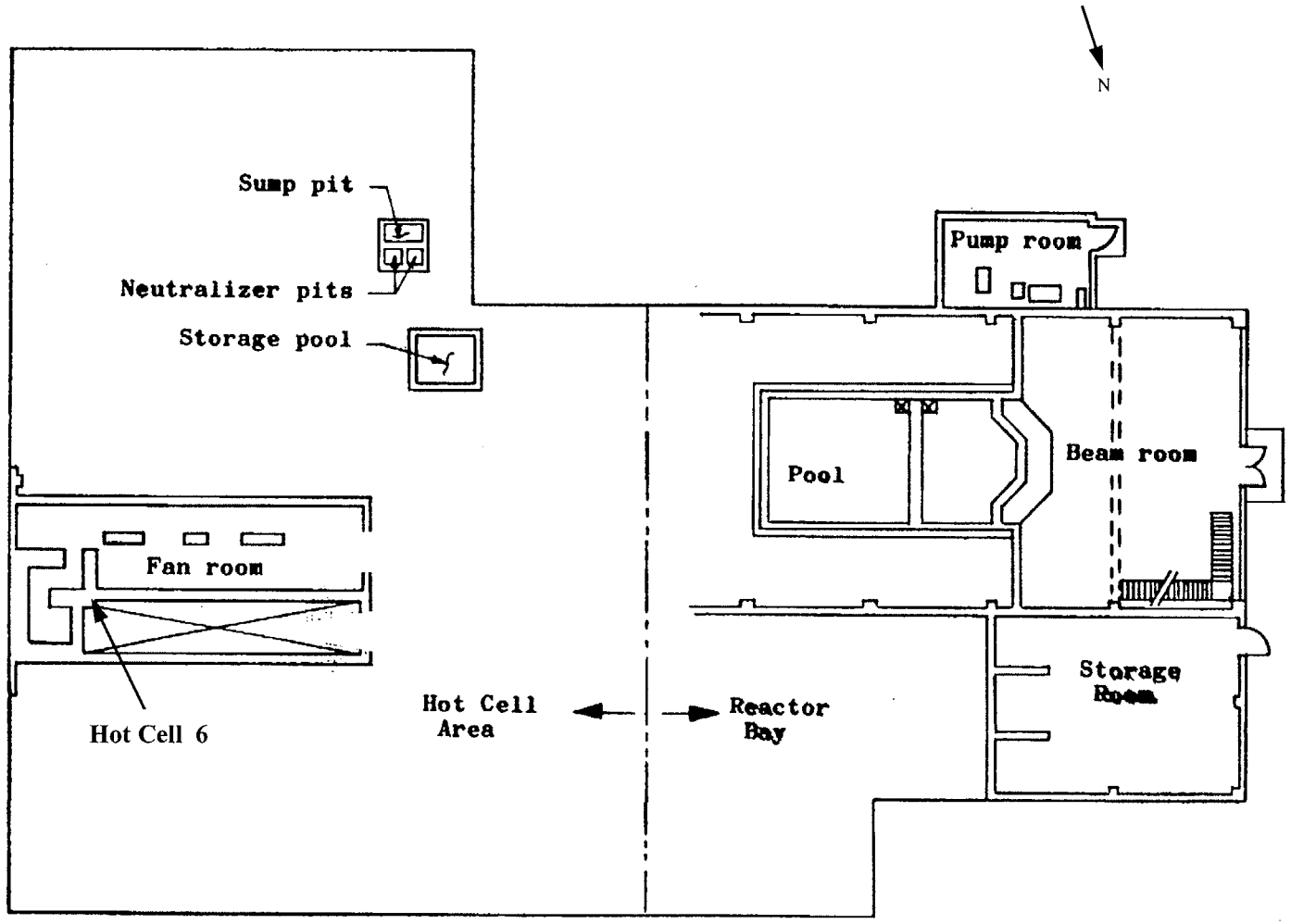
FIGURE 1-1

QUEHANNA SITE LOCATION MAP



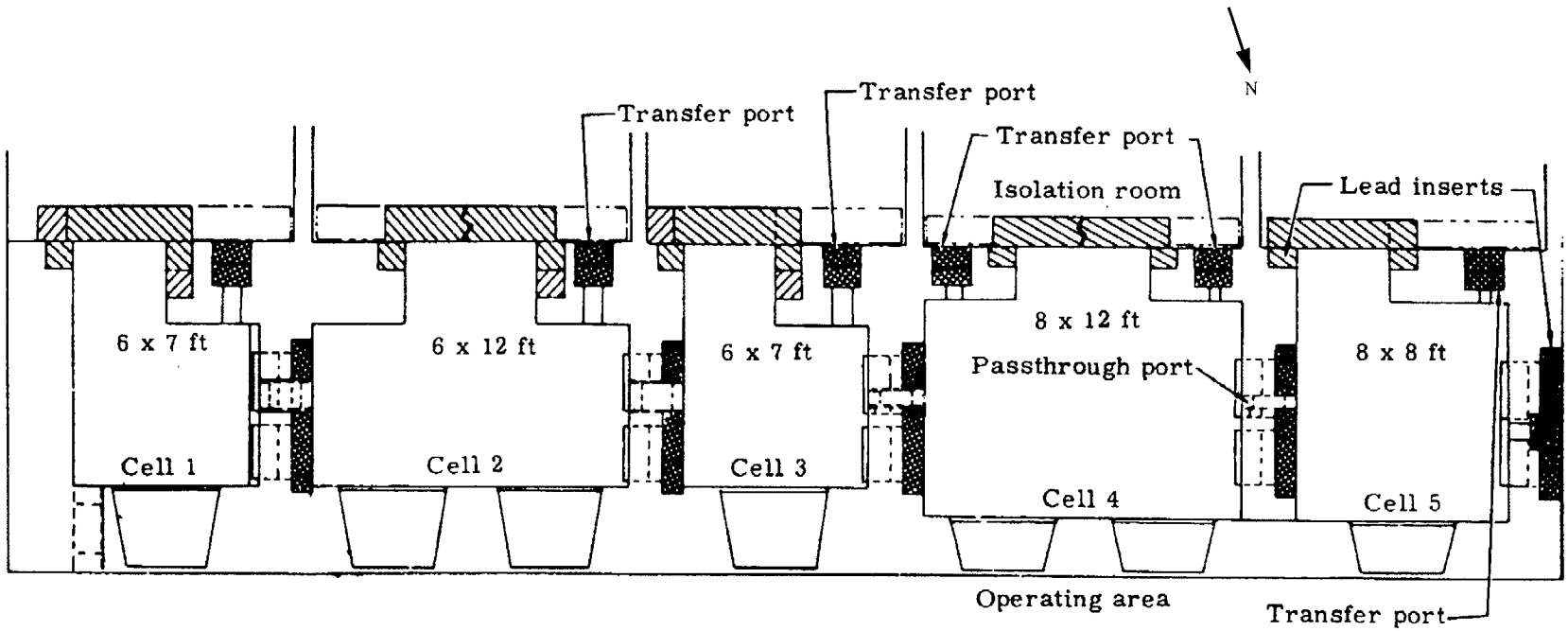
Source: Quehanna Radioisotopes Pilot Plant Engineering Manual, Cell 4 Process Martin Marietta, May 1966

FIGURE 1-2
ORIGINAL MAIN FLOOR PLAN
QUEHANNA FACILITY



Source: Quehanna Radioisotopes Pilot Plant Engineering Manual, Cell 4 Process Martin Marietta, May 1966

FIGURE 1-3
ORIGINAL BASEMENT LEVEL FLOOR PLAN
QUEHANNA FACILITY



Source: Quehanna Radioisotopes Pilot Plant Engineering Manual, Cell 4 Process Martin Marietta. May 1966

FIGURE 1-4
HOT CELLS 1 THROUGH 5
QUEHANNA FACILITY

1.4 LICENSE DECOMMISSIONING

The original objective of the decontamination and decommissioning (D&D) project was to decontaminate and free-release the entire Quehanna site, including newer structures constructed by PermaGrain and terminate NRC license number 37-17860-02. The initial Quehanna Decommissioning Plan was prepared to conform to the regulatory guidance that was in effect at the time it was prepared. The surface contamination release criteria were those provided in the NRC's "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Materials," (NRC 1987), also known as Regulatory Guide 1.86 criteria since the "Guidelines..." release criteria were adopted from the often-referenced Regulatory Guide 1.86 (AEC 1974).

The NRC's "Current Guidelines on Acceptable Levels of Contamination in Soil and Groundwater in Property to be Released for Unrestricted Use" (NRC 1992a) established a release limit of 5 picocuries per gram (pCi/g) average concentration for strontium-90 in soil (15 pCi/g maximum) and 8 pCi/g average concentration for cobalt-60 in soil (24 pCi/g maximum). These were the criteria used in previous Decommissioning Plan revisions for soil contamination.

Under previous revisions of the Decommissioning Plan, the PADEP's Bureau of Radiation Protection (BRP) and its contractor have completed extensive remediation and demolition work at the Quehanna facility. The entire hot cell complex has been removed, including Hot Cell 4, which contained tens of curies of unconsolidated strontium-90 material. In addition, extensive decontamination has taken place on nearly every surface that remains. The following summarizes decommissioning activities that have taken place to date.

1.4.1 Decommissioning Summary

Energy*Solutions*, LLC (formerly Scientech, LLC-D&D Division) mobilized to the Quehanna site in May 1998 and began extensive decontamination and dismantling activities to reduce contamination levels to free-release limits. The following information summarizes the primary D&D activities.

- The WWTB was decontaminated and included the excavation of contaminated tanks, pipes, and soil to about 9 feet (3 meters) in depth).
- Using upgraded manipulator arms, about 2,000 curies of Co-60 from the hot cells was collected, packaged and was shipped for disposal.
- In the reactor pool, the Co-60 sources, irradiator handling equipment, water and sludge was removed. The Co-60 sources were removed by a U.S. Environmental Protection Agency (EPA) contractor under an emergency action contract.
- In the Service Area, most of the dividing walls, much of the floor, and all equipment, including the gantry crane, were removed. In addition, contaminated drain lines below the Service Area floor were excavated along with a limited amount of soil that was affected by line leakage.

- Using robotic dismantlement techniques, the Hot Cell 4 Process System, which contained the bulk of the Sr-90 radioactivity, was removed and packaged for disposal.

- The hot cell complex was removed entirely exposing the basement below (Pipe Chase and Fan Room). The only remaining remnants of the hot cells are two walls and the floor of hot cell six, which was located in the basement. The concrete floor in the basement was subjected to heavy decontamination to meet the release criteria. Some sections of the floor or walls were removed because further decontamination was not practical.

- Interior walls of the Administration Area and PPI support areas were removed and the areas were surveyed and decontaminated to levels below the release criteria. All woodworking equipment sold as part of the PPI bankruptcy was surveyed prior to release. Utilities, fixtures, piping, insulation and building systems were decontaminated as necessary to meet the release criteria.

- In December of 2004, the remediation and Final Status Survey (FSS) of the Quehanna hot cell facility was deemed complete. During the verification survey performed in early May of 2005, however, evidence of recontamination above the 1.86 criteria was found to be present. This is described further below.

1.4.2 Recontamination

The previously unidentified contamination found in 2005 was found to be present in two distinct forms; (1) over one-hundred microscopic hot particles that appeared to have migrated randomly through the structure, and (2), wide-spread low-level spots of fixed contamination which appeared to have leached out of the surface of certain concrete floor areas.

The recontamination event affected the entire interior footprint of the structure with the heaviest concentration of contamination found on the floors of the former Decontamination Room and Radioanalytical Laboratory areas. Both of these rooms are part of the Service Area. To a much lesser degree, additional widespread contamination was found throughout the Administration Area, Service Area, Reactor Bay, and, Finishing Area. Most of the recontaminated areas ranged from just barely over the release criteria to several areas at the 50,000 to 150,000 dpm/100 cm^2 level.

One isolated area measured 7.5 mRad/hr. This was a relatively isolated area in the floor of the Decontamination Room shower stall. Approximately one-half of a millicure was identified in the concrete joints that formed the edges of the shower pan in the Decontamination Room. The radioactive strontium particles apparently migrated closer to the joint surfaces after decontamination and survey activities had ceased. This area was subsequently remediated.

After remediation of the Decontamination Room shower stall, the Administration Area, Reactor Bay, Finishing Area, and Boiler Room floor were completely surveyed twice. Several dozen small spots (less than 100 cm^2) of activity just above the release criteria

were identified during the survey work and were removed utilizing light decontamination techniques. Overhead and walls in all areas were subjected to broad scoping surveys that identified very little contamination above the release criteria in the Service Area. These surfaces were decontaminated as the survey was performed.

1.4.3 Source of Recontamination

The source of the recontamination appears to be multifaceted. Despite attempts to sample and monitor for leaching, some near-surface radioactivity did migrate to surfaces where it was later detected. The migration of Sr-90 in concrete has been studied and is a known phenomenon. The concrete core samples that were previously taken either were free of subsurface contamination or contained subsurface contamination that, when diluted over the entire sample, was present in insufficient quantities to detect.

The other predominant source of activity during the recontamination event was a string of highly mobile, high-activity particles. Although over 100 particles were identified and easily remediated, the source of the particles remains unclear although it is possible that they could have been generated during the diamond wire cutting of the hot cells, been mobilized in the cutting slurry, become hidden in the pores of the remaining concrete and remained undetected through the Final Status Survey. It is theorized that a particle emission "event" could have occurred as the facility and environs experienced a freeze-thaw cycle at the end of winter.

1.4.4 Revised Approach to Site Closure

Although the levels identified in the spring of 2005 could be detected, they did not present a public health concern. Based on this fact, the PADEP has reconsidered its approach to final site closure. Under Title 10 of the Code of Federal Regulations, Part 20, Subpart E, the unrestricted release of a site is to be completed in such a way that the average member of the critical exposure group, which would be exposed to residual radioactivity remaining at the site, receive no more than 25 mrem/yr after the site has been closed and the license terminated. In addition, this dose should be as low as reasonably achievable (ALARA).

PADEP now intends to depart from the Regulatory Guide 1.86-based approach and adopt the contemporary framework for site closure under 10 CFR 20, Subpart E. Having not been maintained for years, the above-grade structures at the site are structurally degraded and pose a severe hazard to inhabitants. As such, the PADEP intends to remove the above grade structures in a timely manner. Debris from the above-grade structures, if found suitable for release, will be placed in a suitable construction landfill. PADEP will fill the subgrade voids primarily using at-grade concrete.

This revision to the Decommissioning Plan, encompasses the dose-based approach to Quehanna Site closure. Dose assessments are conducted later in this Decommissioning Plan to provide for derived concentration guideline levels (DCGL) for debris that will be placed in a landfill, concrete that will be remain at the site, and affected soil that will remain at the site.

2.0 FACILITY OPERATING HISTORY

2.1 LICENSE STATUS

The PADEP currently maintains NRC Radioactive Materials License Number 37-17860-02. The license allows for an unspecified amount of any byproduct or special nuclear material including strontium-90 and cobalt-60. The license only authorizes the D&D of facilities, packaging of stock material and radioactive waste, and storage of material and packaged waste prior to shipment off site. The authorization is limited to radioactive contamination that existed at the facility on January 11, 1988, including specific cobalt-60 sources described in a letter to the NRC dated August 7, 1997. As noted previously, only very low levels of residual radioactivity remain at the facility. All major sources have been removed and disposed of at a licensed facility.

2.2 LICENSE HISTORY

In June 1955, Pennsylvania Governor George M. Leader signed into law several articles of legislation that paved way for the construction of a research facility to be operated by the Curtiss-Wright Corporation at the Quehanna site. The Commonwealth viewed the project as a contributor to the local economy and the Commonwealth acquired the real estate before the advent of Curtiss-Wright. The core area was sold to Curtiss-Wright and the balance of the site leased to them. Early plans for the facility included, among other things, an establishment for the development of nuclear jet engines. They also planned to perform research in nucleonics, metallurgy, ultrasonics, electronics, chemical, and plastics.

Following construction of the Quehanna facility in 1957, the AEC issued a license to Curtiss-Wright in 1958 to operate the swimming pool research reactor at the facility. The facility license also included the use of hot cells, laboratories, and support features. Figures 1-2 and 1-3 show the original floor plans for the main floor and the basement level of the Quehanna facility, respectively. Figure 1-4 provides a more detailed layout of the hot cells.

Licensed isotopic activities began in 1958. In September 1960, Curtiss-Wright donated the facility and land to Penn State. Penn State planned to use the reactor for training and research. They, in turn, leased the hot cells to the Martin Marietta Corporation.

Beginning in 1962, Martin Marietta used the hot cells to manufacture several prototype thermoelectric generators, known as Systems for Nuclear Auxiliary Power (SNAP-7) generators, for the AEC. These power sources, which were designed to furnish power for remotely operated, automatically reporting weather stations, navigation buoys, etc., contained very high specific activity strontium-90 in the form of strontium titanate ($SrTiO_3$).

In the production process, a $SrTiO_3$ precipitate was formed from a strontium nitrate [$Sr(NO_3)_2$] solution by adding inorganic nonflammable reagents. The $Sr(NO_3)_2$ solution was produced by combining strontium carbonate ($SrCO_3$) with nitric acid. The $SrCO_3$, a dry powder, was provided by the AEC's Hanford nuclear weapons facility. The $SrTiO_3$

precipitate was then filtered and dried. The resulting powder was then loaded and condensed and the fuel container was sealed and decontaminated. Measurements were made as needed and the final fuel container was loaded into a generator, cask, or storage facility.

Martin Marietta's radioactive materials possession license allowed them to maintain megacurie amounts of strontium-90. The average shipment of strontium carbonate feed material, which was received from the AEC's Hanford nuclear weapons facility, was about 140 kilocuries. Martin Marietta terminated its lease in 1967 and vacated the facility after a partial decontamination but licensable quantities of strontium-90 remained behind as structural contamination. Martin Marietta was the last licensee to use strontium-90 at the Quehanna facility.

During the Martin Marietta operations, the facility was limited to possess a maximum of 6,000 kilocuries (6 million curies) of strontium-90. Other limitations were established for maximum quantities of strontium-90 within the facility including storage tank T-31 (750 kilocuries), hot cell chamber 4A (150 kilocuries), hot cell chamber 4B (100 kilocuries), hot cell 5 (250 kilocuries) and the material storage pool (2,000 kilocuries). The following radioactive contamination limits in association with the 6,000 kilocuries of strontium were also established:

- strontium-89 — 1,800 kilocuries (50.5 day half-life)
- cerium-144 — 30 kilocuries (284 day half-life)
- other gross fission products — 30 kilocuries

In 1967, Penn State gave its interest in the Quehanna facility back to the Commonwealth and the Commonwealth then leased the facility to NUMEC, a subsidiary of the Atlantic-Richfield Corporation. NUMEC used the pool, which once contained the test reactor, to hold a large cobalt-60 irradiator containing in excess of 1 million curies of cobalt. Projects involving the use of the irradiator included food irradiation, sterilization, irradiation of polymer-impregnated hardwood and other application of intense gamma radiation. The hot cells were used by Atlantic-Richfield for activities involving irradiated mixed oxide fuel.

In 1978, a group of ARCO-NUMEC employees bought the wood irradiation process, including the cobalt pool irradiator and related equipment at the Quehanna facility. The new company, PermaGrain, was issued NRC license number 37-17860-01 for the irradiator and also assumed "caretaker" responsibilities for the radioactive material left behind by previous tenants.

PermaGrain initiated the current NRC radioactive materials license in 1998. This license covered the residual contamination and radioactive materials that remained onsite from the AEC-contract and other operations. The Commonwealth currently owns the Quehanna facility and the surrounding real estate and the DCNR Bureau of Forestry administers the land. The PADEP is currently the official license holder of the 37-17860-02 license, since PermaGrain's filing for bankruptcy in December 2002.

Characterization of the facility identified strontium-90 and cobalt-60 as radioisotopes of concern. One or both of these contaminants were identified in the Hot Cells, the Hot Cells Service and Operations Areas, the Radiochemical Laboratory, the hot cells ventilation system, and in other areas. Within the hot cells, removable strontium-90 surface contamination levels were recorded as high as 3 to 4 rad per hour (rad/hr) per 100 square centimeters ($100cm^2$) and contact dose rates were measured as high as 12,000 rad/hr. At least one concentrated location of strontium-90 isolated inside the Cell 4 process system was measured at 40,000 rad/hr. Strontium-90 contamination was inadvertently spread throughout the Quehanna facility over the years resulting in numerous areas of dispersed low-level contamination.

2.3 ISOTOPES OF CONCERN

Extensive survey work that had been completed up until the point of the FSS and the extensive data collected as part of the FSS have all indicated that cobalt-60 did not migrate from the hot cells in which they were housed. No isotopes have been seen during the entire project other than cobalt-60 and strontium-90.

2.4 PREVIOUS DECOMMISSIONING ACTIVITIES

Limited information was available on the extent of the decontamination effort provided by Martin Marietta or ARCO-NUMEC prior to their vacating the Quehanna facility. Therefore, the PADEP contracted Canberra Industries, Nuclear Services Division to perform a facility characterization in the early 1990s. Based on this D&D activities have been underway at the Quehanna facility since 1998 under the methods and procedures outlined in Revision 1 of the Decommissioning Plan. The Decommissioning Operations Contractor (DOC) has removed significant volumes of contaminated material to reduce the on-site radiological hazard and has decontaminated much of the facility in order to reduce the volume of radioactive waste.

2.4.1 Hot Cells

The Hot Cells structure was located inside the Service Area. The Hot Cells were used for Sr-90 activities beginning in 1962 and ending in 1967. There were 5 hot cells (Hot Cells 1 – 5) on the main level of the Service Area and one hot cell on the basement level (Hot Cell 6). Besides Hot Cell 6, each hot cell had an associated isolation room located between the hot cell and the Service Area. In 1998, a total of approximately 2,000 Ci of Co-60 sources were removed from Hot Cell 1 and Hot Cell 5. Hot Cell 4 was found to be the most contaminated area of the facility with tens of curies of Sr-90 contamination. Hot Cells 1 through 5 and their associated Isolation Rooms were completely dismantled and removed using diamond wire cutting. Only the outside walls and floor of Hot Cell 6 remain.

2.4.2 Service Area, Chemistry Lab, Decontamination Room, Fan Room, and Pipe Chase

In addition to the Hot Cells and their Isolation Rooms, the Service Area also contained the Chemistry Lab, the Decontamination Room, the Janitor's Room, and the Laundry Room on the main level and the Fan Room and Pipe Chase on the basement level. Eight Ci of dispersed Sr-90 contamination was suspected in the Service Area and its associated rooms prior to D&D activities. Most of the Service Area's concrete floor was removed because of resilient, low-level contamination. Underlying drain piping was removed as well along with a limited amount of soil that exhibited elevated radioactivity from pipe joint leaks. After removal of the contaminated soil, confirmatory samples were taken to ensure all of the affected soil was removed. Clean fill was added to restore the area to grade level. Most of the dividing walls were removed and all of the utility services and the bridge crane were also removed.

The basement level known as the Pipe Chase and Fan Room, which are divided by a concrete wall, was the center of the most extensive decontamination work. An average of approximately eight inches of concrete was removed from the surfaces in this area to meet the release criteria. The basement structure had no seams (monolithic pour); therefore, it was effective in containing the contaminants. This was confirmed by substructure sampling, which is discussed in Section 4.0.

2.4.3 Reactor Bay

This area contains the reactor pool, which once contained a swimming pool type research reactor as well as PPI's Co-60 irradiator and an extensive amount of material handling equipment. Sr-90 contamination was thought to be possible because of its proximity to the Service Area where the hot cell complex was located. The Reactor Bay ceiling and wall panels were virtually free of contamination but the horizontal surfaces of the support structure (I-beams) had random spots of contamination. This appears to have been associated with tracking from birds that inhabited the building. No information existed to suggest that operational events would have contaminated the Reactor Bay above the floor.

The lower level of the Reactor Bay had nuisance levels of radioactive contamination, which probably originated from the hot cells. This contamination was identified in utility trenches and their covers, and on horizontal surfaces. Due to the build up of PPI's polymer, MMA, and years of dust and grime, extensive cleaning of much of the area was necessary to allow an accurate radiological survey.

2.4.4 Reactor Pool

As stated before, approximately 100,000 Ci of sealed Co-60 source rods were removed from the reactor pool by EPA contractors in September of 2003. Records indicate there was never leakage from the Co-60 sources. Surveys of the pool, support systems, and resin purifiers support this contention. Structural material, however, could have been activated at low levels by test reactor operations prior to the installation of the irradiator. In addition, the pool was located near the hot cell complex, which could have allowed for cross contamination.

To support the FSS process, the irradiator handling equipment, which moved encased wood products through the irradiators, was removed from the pool. Remaining sludge was dewatered, removed, and solidified. A very limited amount of Sr-90 contamination was found in the sludge; therefore, the sludge was disposed of as radioactive material. After cleaning, the reactor pool was subjected both to a contamination survey and a radiation survey with a NaI detector to detect activated material. One of the three activation port plugs (the center one) was found to be slightly activated and was disposed of as radioactive waste. Otherwise, the reactor pool was found to be suitable for release.

2.4.5 Pump Room

The Pump Room is located on the west side of the facility at the lowest level. It is accessible from the paved area between the facility and the pond. The components located in the Pump Room make up the reactor pool purification and water handling system. Components include deionizers, recirculation pumps, and other operational equipment. The Pump Room and its components were thought to have about the same potential for contamination as the reactor pool. After removal of dirt, grime and debris, the Pump Room was surveyed and found to be suitable for release.

2.4.6 Waste Water Treatment Building (WWTB)

The WWTB is a small building west of the Finishing Area. This building once housed an evaporator and water purification system that supported operations of the hot cell complex. All of the purification equipment in the building had been removed some time after hot cell operations were terminated and the building had afterwards been used by PPI to house a wood burner. Underground water storage tanks associated with the WWTB and piping, however remained. In 1998, the DOC excavated these tanks and their piping (also addressed in next Section). As part of this effort, Sr-90 contamination above the release criteria was found in the WWTB as well as in the soil. The contamination was removed as part of the 1998 effort and was verified as part of the 2004 FSS.

2.4.7 Finishing Area

The Finishing Area was constructed and used by PPI in its wood flooring production process. While no radioactive materials were used, processed, or stored in the area prior to site D&D operations, sections of the Finishing Area were used to store concrete blocks that once made up the hot cell structure. These blocks were sealed with paint to reduce the possibility for contamination, but contamination levels greater than the release criteria were later found on parts of the Finishing Area floor. Surveys of the walls and ceiling showed that they were not impacted. The southwestern corner wall of the Finishing Area received a higher level of scrutiny since a decontamination tent, used for decontaminating concrete blocks from the hot cell complex, was placed in that area.

Located on the north side of the Finishing Area between the Finishing Area Office and the Boiler Room is a small room known as the Tool Crib which was used for storing equipment during PPI operations. This area was used by the DOC to store LLRW. The Finishing Area Office, located on the north side of the Finishing Area, was never used for radiological operations.

2.4.8 The Electrical Room, Hydro-Blast Area, Dungeon, and the Sawdust Shed

While considered potentially impacted, these areas were not considered likely to be contaminated based on facility-use knowledge and scoping surveys. The Sawdust Shed collapsed in September 2004; however prior to this, a FSS was conducted.

2.4.9 The Roof

Access to the roof was a safety concern due to its instability. Although limited repairs to minimize leakage have been made, it was unsafe to walk on. There was no reason to believe that the roof was impacted; however, two ventilation discharge ports, which were accessible using a man-lift, were surveyed as part of the FSS. No elevated levels of radioactivity were identified.

2.5 SPILLS, UNCONTROLLED RELEASES, AND ON-SITE BURIALS

Site characterization activities resulted in the identification of many areas of surface contamination within the facility structures and limited areas of soil contamination. Soil contamination was identified and remediated in the following areas:

- Below the WWTB
- Near drain piping under the Service Area floor
- Under the trench that was directly under the hot cell face (Cell Operations Area).

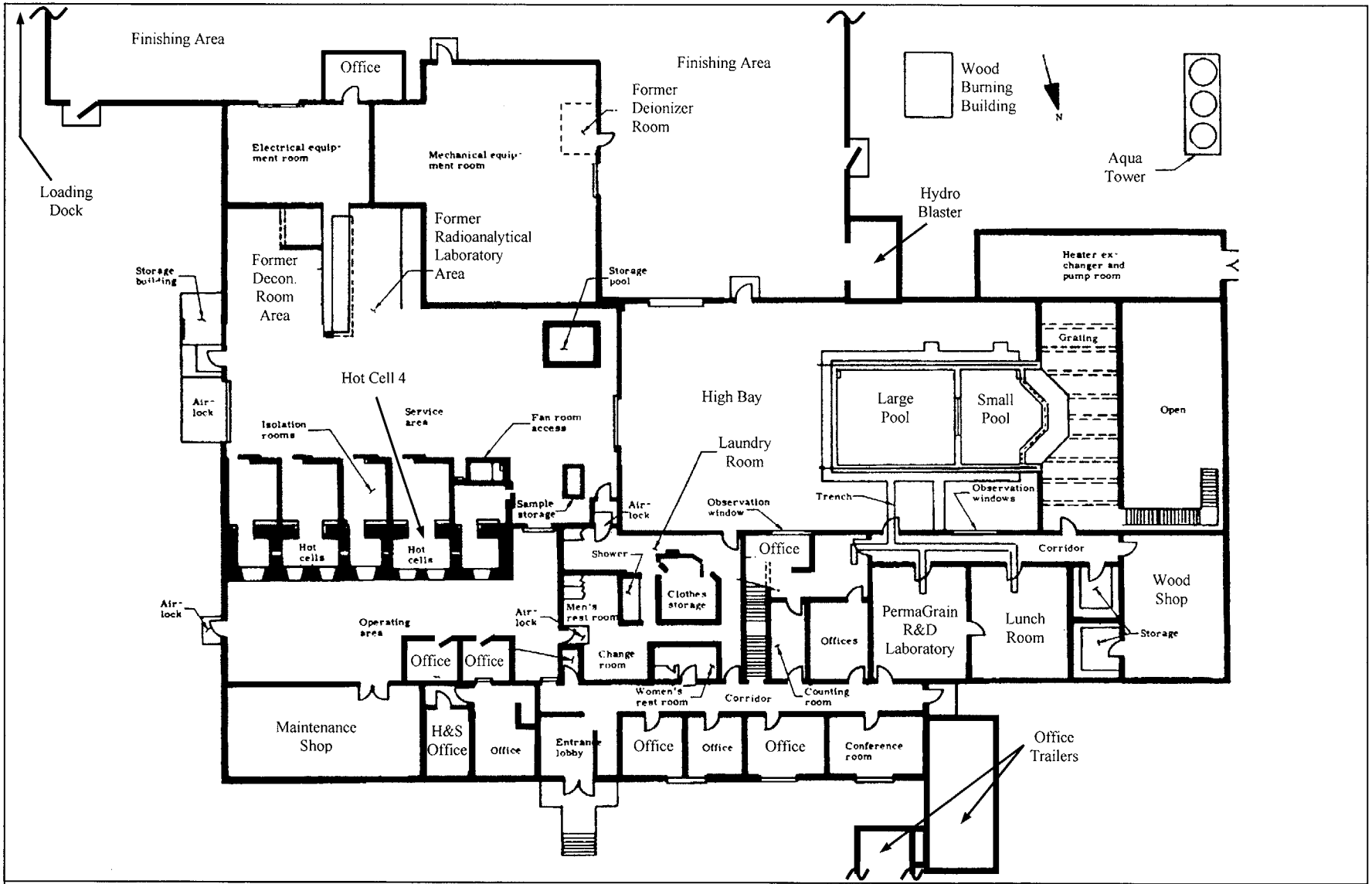
Post remediation sampling in these areas and extensive soil sampling conducted as part of the FSS have indicated that no additional soil contamination exists above the 5 pCi/g (Sr-90) criteria that has been used.

On Monday, October 12, 1998 contractor personnel used a hand-held shearing device to cut out a short piece of process tubing in the Hot Cell 4 Annex in an attempt to reduce exposure rates for future dismantling activities. Subsequent to removal of the tubing, during a routine frisk, contractor health physics personnel identified one worker who handled the tube as being contaminated with strontium. Further investigation by radiological personnel showed that contamination from the tube migrated from the Annex to the Cell 4 Isolation Room, Service Area, and Operations Area (see Figure 2-1). Two other contractor employees were also contaminated who were directly involved in the removal and handling of the tube. Very low levels of strontium surface contamination were also discovered in the PermaGrain reception area (labeled "Entrance Lobby" on Figure 2-1). The PermaGrain areas contaminated during this incident, including the reception area, were decontaminated shortly after the incident. The reception area was released without restrictions. The other contaminated areas are located inside previously defined controlled areas. Details of this contamination event including personnel dose assessments were fully documented in a subsequent report to the NRC.

This incident demonstrated the need for a durable containment system and controlled ventilation for future Cell 4 D&D operations. Additionally, the high radiation levels discovered during subsequent investigations inside Cell 4 in 1999 were the primary factor in choosing a robotic approach to the decontamination and dismantling of Cell 4. As a

result of the 1998 incident, Cell 4 was put into a standby mode described in Amendment 7 of the NRC license.

There are limited records that indicate that burials were conducted adjacent to the access road that serves the Quehanna Facility. These areas have been previously examined; once in 1963 (Letter to H.J. Knoll) and again in 1983 (Letter to T.M. Gerusky). An extensive radiological investigation was also performed for NRC by Oak Ridge Associated Universities in the late 1980's. The final report, "Radiological Survey of the Quehanna Wild Area, Karthaus, Pennsylvania" by D.R. Styers was finalized in 1987. These evaluations have indicated that the suspect areas are not believed to pose a health threat.



Source: Quehanna Radioisotopes Pilot Plant
Engineering Manual, Cell 4 Process
Martin Marietta, May 1966
Updated in 2002 based on information provided by PermaGrain Products, Inc. and EnergySolutions, LLC.

FIGURE 2-1
CURRENT MAIN FLOOR PLAN
QUEHANNA FACILITY

3.0 FACILITY DESCRIPTION

3.1 SITE LOCATION AND DESCRIPTION

The Quehanna site is located at 115 Reactor Road, Karthaus, Clearfield County, Pennsylvania. The site, located at approximately 41° 13' north latitude and 78° 14' west longitude, is about 9 miles from downtown Karthaus and approximately 21 miles northeast of Clearfield, Pennsylvania. Figure 1-1 provides a topographic map showing the general location of the site within the Clearfield County near the boarders of Elk and Cameron Counties (USGS 1971).

The Quehanna site is located in the Quehanna Wild Area of the Moshannon State Forest at an elevation of 1,860 feet above sea level. The area surrounding the site is heavily forested. The topography is typical of the Appalachian Plateau such that the area is relatively flat with an average elevation of 2,000 feet above mean sea level. The edge of the facility property is incised by several gorges up to one-half mile in width and 1,000 feet in depth that radiate from their origin near the center of the site. The area around the site also has a significant number of granite outcroppings that are characteristic of the region.

The nearest population centers to the Quehanna facility are Sinnemahoning and Karthaus, each about nine miles away. The nearest residents to the site are located at the Quehanna Boot Camp, owned and operated by the Pennsylvania Department of Corrections. The Boot Camp, located approximately five miles east-northeast of the Quehanna facility, is a military-style motivational boot camp. The minimum-security Boot Camp typically houses about 200 inmates, both male and female, and supports a staff of about 150 administrators, Corrections Officers, and other support personnel.

The Quehanna site is approximately 7-acres in size and has been improved with several permanent and temporary structures, an asphalt parking lot, and several paved and gravel driveways. The original primary structure included the hot cells area and the reactor bay. Original laboratory and office areas are also still in use (see Figure 1-2). Several areas previously occupied by PermaGrain have been added onto the primary structure to support their wood treatment operations (see Figure 3-1). The site also includes a small 0.5-acre pond and a septic system leach field that is used to manage sanitary sewer waste from the facility. Several aboveground storage tanks are used to store methylmethacrylate (MMA), the polymer chemical used in PermaGrain's wood treatment process. The tanks are located west of the main facility structure and north of the pond. A small stream bisects the site property north of the facility's main building and parking lot. Figure 3-1 shows the layout of the Quehanna site.

3.2 POPULATION AND LAND USE

The Moshannon State Forest surrounds the facility and has a low permanent population density. Within a 25-mile radius of the site, the population density is approximately 27 individuals per square mile with a total population of about 54,000. Table 3-1 provides population centers by county and their 1999-estimated population for the area within a

25-mile radius of the Quehanna facility. The population of the 25-mile radius area has remained almost constant for the last 35 years.

TABLE 3-1
POPULATION ESTIMATES FOR AREAS NEAR THE QUEHANNA SITE

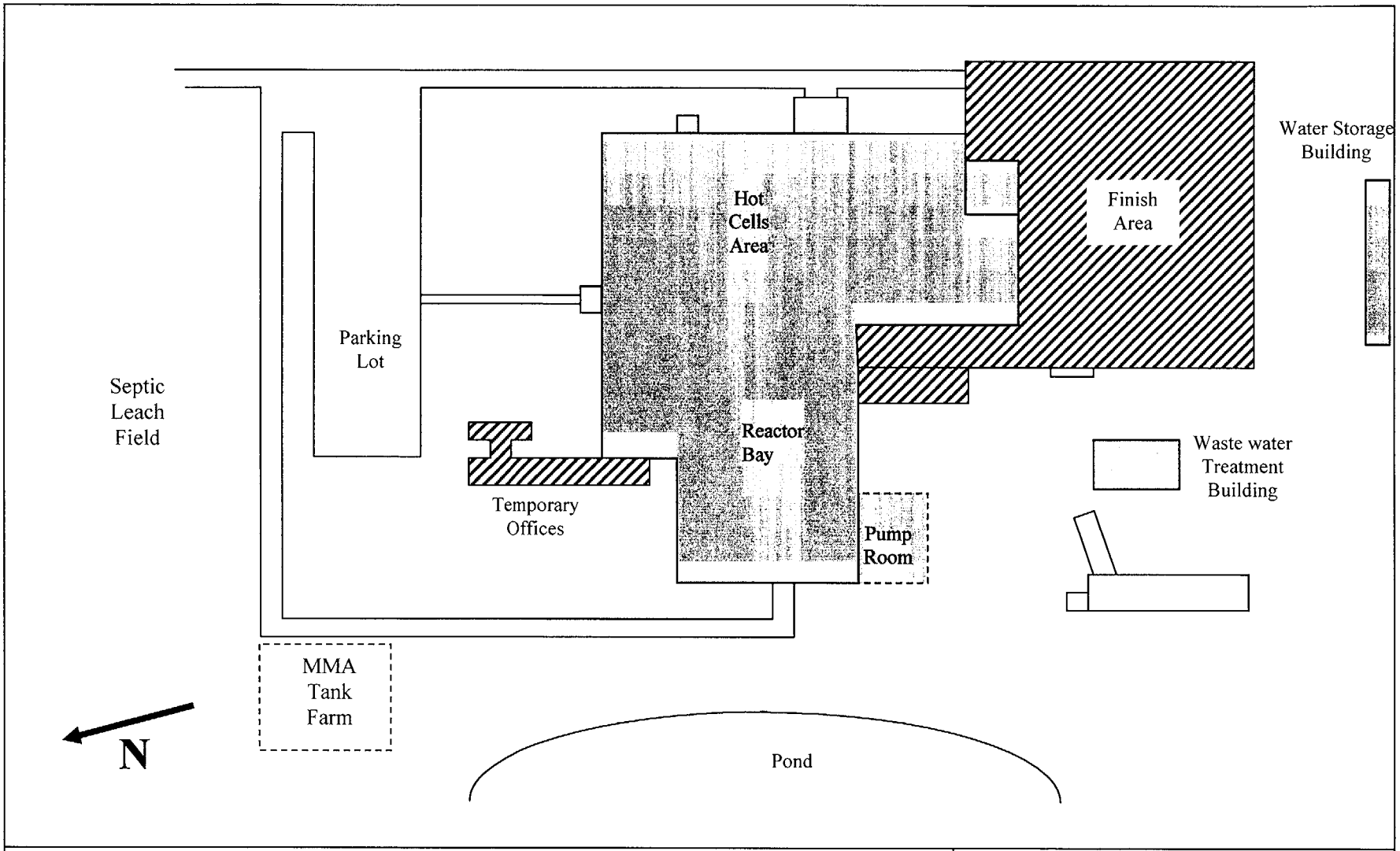
Population Centers			
City/Town/Village (County)	**Population**	**City/Town/Village (County)**	**Population**
Driftwood (Cameron)	110	Clearfield (Clearfield)	6,516
Emporium (Cameron)	2,303	Curwensville (Clearfield)	2,937
Bellefonte (Centre) *	6,022	Dubois (Clearfield) *	8,006
Howard (Centre)	713	Osceola Mills (Clearfield)	1,284
Philipsburg (Centre)	2,875	Wallaceton (Clearfield)	329
State College (Centre) **	39,017	Johnsonburg (Elk) *	3,153
Snow Shoe (Centre)	806	Ridgeway (Elk) *	4,423
Chester Hill (Clearfield)	932	Saint Marys (Elk)	13,830

County Totals		
County	**Total of Above Areas**	**Balance of County**
Cameron	2,413	3,158
Centre	49,433	82,757
Clearfield	20,004	60,728
Elk	21,406	34,344

Source: U.S. Census Bureau internet site, www.census.gov
Notes:
* Town slightly outside the 25-mile radius of the Quehanna facility
** State College is 45 miles southeast of the Quehanna facility

Based on 1998 census estimates, the percentage of minorities in this area of Pennsylvania is very low. The minority populations for Cameron, Clearfield, and Elk Counties, which surround the site in all compass directions, are less than one-percent. The minority population in Centre County is about nine-percent, with most of the minority population residing in State College, 45 miles southeast of the Quehanna facility. According to 1995 census estimates, between 10 and 15 percent of the population lives below the poverty line in Cameron, Centre, and Clearfield Counties. In Elk County, approximately eight-percent of the population lives below the poverty line.

Non-residential land in the vicinity of the Quehanna facility primarily supports seasonal recreation activity including hiking, camping, and hunting. Beyond the Moshannon State Forest, within the outlying communities, there is also small-scale agricultural activity. Because of the areas designation as a State Forest, uses of the surrounding land are unlikely to vary from the current uses.



New PermaGrain Areas

Original Hot Cell and Reactor Service Areas

Drawing not to scale

FIGURE 3-1
QUEHANNA FACILITY LAYOUT

3.3 METEOROLOGY AND CLIMATE

Comparatively short cool summers and long cold winters with 40 to 50 inches of precipitation well distributed throughout the year characterize the climate of the Quehanna area. Average summer temperatures are near 68°F with highs in low 80s and lows in the mid 50s. Many of the winter months have mean temperatures below 25°F with January 1918 being the coldest month of record when temperatures averaged 13°F and the monthly mean low was 3°F. The daily temperature range is generally smaller in winter than in any other season due to widespread cloudiness that is prevalent from late November through March.

Although daytime temperatures normally reach into the 50s by April and into the low 70s in May, nights remain cool until mid May. The average date of the last 32°F-temperature in spring is May 19. In the fall the average date of the first 32°F-temperature is September 29, even though daily highs climb into the 60s in October. Year-to-year variations in weather patterns have resulted in 32°F-temperatures as late as mid June and as early as the end of August over the period of record. The growing season, defined as the interval between the last 32°-temperature in spring and the first in fall, averages 133 days, but seasons have ranged from 100 to 170 days.

3.3.1 Wind Flow and Air Quality

The predominant wind directions at the Quehanna site are from the west-northwest and the south-southeast. From a population distribution standpoint, these are favorable in the event of an accidental release from the Quehanna Site since they are not directed at the major population centers of the region or into areas with above average population density.

Wind speeds during daylight hours vary from a maximum average of about 12 miles per hour (mph) in the spring to about eight mph in the summer. Nighttime speeds are somewhat lower, with a highest average wind speed of about 10 mph in the winter to a lowest average speed of about four mph in the summer. Maximum wind speeds are generally from the west with a maximum sustained wind speed of 50 mph and peak instantaneous gusts of 80 to 90 mph. The most frequent winds are between 4 and 12 mph.

In the period between 1930 and 1965, only five tornadoes were reported in the five-county area around the site. Fifteen tornadoes were reported in the five-county area between 1965 and 1995. A tornado passed very close by the Quehanna facility in 1985 laying a path of downed trees over 100 yards wide and ripping the roof off of parts of the facility structure.

The PADEP, Bureau of Air Quality, has two air quality monitoring stations in Centre County south of the Quehanna facility. One monitoring station is located in State College and the other is located 10 to 12 miles south of State College. During the period from January 2000 through December 2000, the pollutant standards index was in the "Good" range 156 days and in the "Moderate" range for 56 days (PADEP 2001). No days were reported as "Unhealthful," "Very Unhealthful," or "Hazardous."

3.3.2 Precipitation

The average annual precipitation at the Quehanna Site is estimated to be between 40 and 50 inches per year. Maximum precipitation occurs in May through July and the minimum precipitation occurs in November and December. The average precipitation is 2.5 to 4.5 inches per month; however, because of the frequency of storms, precipitation is quite variable. Amounts of as much as 1.7 inches in one hour and 7.5 inches in 24 hours have been observed in the area. Dry spells may develop at anytime but are most numerous during summer and fall.

From November through March most of the precipitation is in the form of snow that is both frequent and abundant. Snowfall is estimated to be an average of about 40 inches per year. Heavy snowfalls are not uncommon resulting in up to 10 inches in a single storm. The maximum snowfall recorded in a 24-hour period was 20 inches. A snow cover of varying depths is present most of the winter season.

3.4 GEOLOGY

The Quehanna Site lies near the northeastern edge of the Pittsburgh Low Plateau physiographic province of Pennsylvania (DCNR 2000). The province is dominated by smooth to irregular undulating surface and, narrow, relatively shallow valleys with low to moderate local relief. The underlying rock types include shale, siltstone, sandstone, limestone, and coal. The origin of the province is fluvial erosion and periglacial mass washing (DCNR 2000).

The Quehanna Site area consists of three major geologic formations present at various depths below the ground surface. The surficial formation, the Pottsville formation, extends to about 200 feet below the ground surface. The Pottsville formation is of the Pennsylvanian Age (290 to 330 million years) and consists of massive coarse-grained gray-to-white sandstone with large pebbles. The sandstone is a productive water-bearing formation below drainage levels and generally yields small to moderate supplies elsewhere.

The Pottsville formation is underlain by a formation of Mauch Chunk shale from the Mississippian Age (330 to 365 million years). The shale formation is about 50-feet thick and is characterized by red and green argillaceous shale with some sandstone. This formation is not generally exposed and it is not a water-bearing horizon. The formation likely forms an impervious strata retarding downward percolation of water in most areas.

The 600-foot thick Knapp (Pocono) formation lies under the Mauch Chunk formation. This formation is from the Mississippian or Devonian Age (365 to 405 million years) and is characterized by a succession of alternating olive-gray, gritty, micaceous sandstones and gray-green argillaceous shales. These interbedded layers form the steep slopes of the gorges in the area. The formation can be a productive water-bearing formation below the drainage layer.

3.5 STRUCTURE AND SEISMOLOGY

In the Quehanna Site area, the geologic beds are generally horizontal and demonstrate the lack of structural disturbances in the area. In the northern portion of the site area, there is field evidence of gentle folding. The physiographic province is characterized by a geological structure has low- to moderate-amplitude open folds, decreasing in occurrence northwestward. Faults, joints, and fractures are probably not abundant at the site and the area is considered geologically stable.

Geological hazards in Pennsylvania include landslides, sinkholes, and earthquakes. Case histories of sinkhole occurrence reveal that sinkholes occur only in certain parts of Pennsylvania in areas that are underlain by carbonate bedrock. These areas are located in the central to southeastern portions of the state and do not include Clearfield County (DCNR 1999a). The Pittsburgh Low Plateau physiographic province of Pennsylvania, which includes northern Clearfield County and the Quehanna facility is considered high to moderately susceptible to landslides (DCNR 2001). Earthquakes are also rare in this part of Pennsylvania.

The only recorded earthquake with its epicenter in one of the five Pennsylvania counties in the area of the Quehanna Site was in Centre Hall, Centre County, on August 15, 1991. That quake registered a 3.0 on the Richter scale. The epicenters of quakes in Susquehanna, Centre, Blair, and Somerset Counties fall roughly along the Allegheny Front, the position of which may reflect an antecedent tectonic feature, possibly the Iapetan rift margin of Laurentia. Epicenters in northwestern Pennsylvania appear to represent a westward extension of the western New York seismic zone, which itself may be an extension of the zone of seismicity along the St. Lawrence Paleozoic rift. Thus, all Pennsylvania seismicity may be caused by reactivation of faults associated with crust that experienced Paleozoic or Mesozoic rifting.

Complete earthquake histories of Pennsylvania and the states that are within a 200-mile radius of the Quehanna site can be found on the U.S. Geological Survey web site, www.neic.cr.usgs.gov/neis/states.

3.6 HYDROLOGY

3.6.1 Surface Water Hydrology

Surface drainage from the area surrounding the Quehanna facility is from four major radial streams; Mix Run (north), Wykoff Run (northeast), Upper Three Run (southeast), and Mosquito Creek (south). The former two streams drain into Sinnemahoning Creek, which flows into the west branch of the Susquehanna River. The later two streams drain directly into the Susquehanna River.

Of prime interest are Reactor Run and Meeker Run, the primary creeks that drain the Quehanna facility site. Surface water around the Quehanna facility flows into Reactor Run and then successively into Meeker Run, Mosquito Creek, and ultimately into the west branch of the Susquehanna River. The river has a rather large average flow rate of more than 2,400 cubic feet per second (cfs) at Karthaus, Pennsylvania with maximum

and minimum flows rates approximately 51,000 and 100 cfs, respectively (Martin Marietta 1964). There is no available data on the flow of the smaller runs and creeks.

A pond, about 0.5 acre in size, is located west of the Quehanna facility outside of the fence line. A man-made earthen dam is located on the western side of the pond. A spill way allows water from the pond to flow though the dam into Reactor Run Creek and eventually into Meeker Run Creek. The water source of the pond is surface water run-off from the Quehanna Site area and at least one underground spring.

Formerly, water for the facility was obtained from a dam on Meeker Run Creek. The dam was located upstream from the facility and was capable of releasing water at a rate of 120 gallons per minute. There are two additional reservoirs within the surrounding site area, both of which are several miles from the facility.

Due to the site's location, elevated nearly 300 feet above Meeker Run and Mosquito Creeks, the possibility of the site flooding is extremely unlikely.

3.6.2 Subsurface Hydrology

The predominant aquifer in the area is contained in the Pottsville formation, though it is not very productive. Since the Pottsville formations form the surface exposure of the area, it collects water and transmits it downward to a saturated sandstone member about 40 feet thick near the interformational contact with the impervious Mauch Chunk shale formation. Streams cutting the Pottsville provide secondary recharge. Discharge occurs at springs at the interformational contact. The evapotranspiration rate for the area is 4 to 8 inches per year.

The underlying impervious Mauch Chunk shale prevents downward transmission of potential contaminants released to the Pottsville formation. Lateral transmission within the Pottsville aquifer would be of a somewhat limited nature and would not pose a significant subsurface contamination problem in the light of the large unpopulated area surrounding the facility. In fact, movement of soluble contaminants within the Pottsville formation would be on the order of tens to a few hundred feet per year (DeBuchananne 1956).

The groundwater in Clearfield, Elk, and Cameron Counties is used for public and private water supplies. The percentages of public water that comes from groundwater sources in Clearfield, Elk, and Cameron Counties are 36%, 8% and 35%, respectively. The percentages of homes that have private wells in Clearfield, Elk, and Cameron Counties are 20%, 37% and 37%, respectively. Each of these counties has 15 to 29 private wells per square mile (DCNR 1999b).

3.7 NATURAL RESOURCES

Natural resources in the five counties in the area surrounding the Quehanna facility include primarily timber, minerals, oil, natural gas, and to a lesser extent, brine and agriculture. However, the most significant natural resources in the immediate vicinity of the facility are the Moshannon State Forest and the Quehanna Wildlife Area.

In recent years there has been an increasing demand for types of recreation that only large tracts of forestlands such as the Moshannon State Forest can provide. Traditional outdoor activities such as hunting and fishing have been stable, but such things as cross-country skiing, mountain biking, backpacking, horse back riding and motorized recreational activity increase each year. Some of these have required the construction of new or the upgrading of older trails systems. Maps have been created for a number of the specialty trails.

The Quehanna Wild Area is set aside to maintain the undeveloped character of the forest environment. This 50,000-acre area was originally state forestland that was transferred to the Curtiss Wright Corporation for jet engine and nuclear research in 1955 and returned to the Commonwealth in 1966. Today this area shows the stark evidence of extensive oak leaf roller mortality and the massive destruction caused by the 1985 tornado. Natural regeneration has become evident on a number of these sites, holding the promise of a future forest. The Quehanna Wild area is jointly administered by the Moshannon and Elk Forest Districts of the Pennsylvania DCNR. Certain special regulations guide the types of activities that are permitted in the wild area. Contact the district forester for more details.

The near-by 975-acre Marion Brooks Natural Area is the site of a pure stand of white birch trees. It is adjacent to the Quehanna Wild Area. This area is preserved so that nature may take its course, free from human intervention.

There are three State Parks within the Moshannon State Forest. Two of them are administered from the same office. They are: Parker Dam State Park, S.B. Elliott State Park, and Black Moshannon State Park.

3.8 ECOLOGY AND ENDANGERED SPECIES

Wildlife in the area of the Quehanna facility is diverse and includes populations of large mammals including elk, bear, and deer. The Quehanna facility is located on the northern edge of state designated game lands Area No. 34. The primary game in the area includes bear and deer. In 1999, the harvesting totals for bear, antlered deer, and antlerless deer in the five counties in the Quehanna area were 476, 17,572, and 12,867, respectively. There are no known commercially or recreationally important invertebrate or floral species located in the vicinity of the Quehanna facility.

The statewide elk population, which has risen from less than 100 in 1971 to almost 600 in 1998, is concentrated in the Quehanna Wildlife Area. Although the population has been successfully re-established in the area, elk hunting is not currently allowed by the Pennsylvania Board of Game Commissioners.

Creeks and streams within the immediate vicinity of the Quehanna site can provide brook and brown trout to recreational fisherman. Parker Dam State Park and S. B. Elliott State Park, each located within 15 miles of the Quehanna facility, are popular destinations for recreational fisherman. The streams and ponds at the parks support populations of trout, bass, bluegills, crappie, and catfish.

There are several federally endangered species in Pennsylvania. These species include the bog turtle, the peregrine falcon, the short nose sturgeon, the Indiana bat, and the Delmarva fox squirrel. The bald eagle, now federally designated as threatened, is also present in Pennsylvania. The proximity of breeding populations of these endangered or threatened species to the Quehanna facility is not known. Additionally, 20 percent of the state's native vascular plants are designated as endangered by the state. It is uncertain if any of these plants are located at the Quehanna facility. However, Pennsylvania Natural Diversity Inventory (PNDI) information system records do not indicate occurrences of plant or animal species of special concern within a five-kilometer radius of the Quehanna site (PNDI 2001).

Remaining Quehanna D&D operations will be conducted within or adjacent to the perimeter of the former industrial complex. Activities beyond the perimeter of the site will likely be limited to environmental sampling and transportation of equipment and waste along existing roads. Therefore, it is not anticipated that the D&D activities will have an impact on the surrounding ecology or specific endangered, threatened, or rare species.

4.0 SOIL/LAND AREA RADIOLOGICAL CHARACTERISTICS

The following section provides a summary of soil and land area analyses that have been completed over the course of the project including the FSS work.

4.1 INITIAL SITE CHARACTERIZATION

During site characterization in 1991, the characterization contractor collected a limited number of off-site surface soil samples. The analytical results, which are provided in the Canberra characterization report, showed no off-site impact to the surface soils from site activities. Of 18 soil samples, only 6 showed strontium-90 concentrations greater than the analytical method detection limit. Of these six samples, the average strontium-90 concentration was 0.27 pCi/g with a maximum concentration of 0.55 pCi/g ± 31%, consistent with background levels.

4.2 ADDITIONAL SITE CHARACTERIZATION

In November 2000, the DOC conducted a scoping-level surface and subsurface soil sampling effort covering a large portion of the Quehanna facility. The characterization was designed to investigate areas that most likely would be impacted by site activities. These areas included the sanitary sewer leach field located north of the facility parking lot, the area immediately east of the Hot Cells Service Area, the area south of the Reactor Bay, the outfalls from the former WWTB, and the reactor pool and locations directly below the Operations Areas.

As part of the soil characterization, The DOC collected approximately 200 soil samples from locations on and off of the Quehanna site with most of the samples taken from around or beneath the Service and Reactor Bay areas. The soil samples were first analyzed using an on-site gamma spectrometer for gamma-emitting contaminants. No gamma-emitting radionuclides were identified above background concentrations in any of the soil samples. Following the gamma spectroscopy analysis, 50 samples were sent off-site for analysis for strontium-90 (EPA Method 905.0/SM704). The sample with the highest strontium-90 concentration, 4.3 pCi/g, was collected from under the Decontamination Room concrete slab floor. The clean-up/release level for strontium-90 was 5 pCi/g. Table 4-1 provides a summary of the 50 soil samples that were analyzed for strontium. Those samples that contained strontium-90 at levels greater than 0.91 pCi/g (the mean concentration plus one standard deviation) are described in Table 4-2. All of these areas were later remediated during different times of the decommissioning project.

TABLE 4-1
SUMMARY OF STRONTIUM-90 SOIL SAMPLES (November 2000)

Summary Statistic	Value
Number of samples	50
Maximum value[a]	4.3 ± 0.62 pCi/g
Minimum value[a]	-0.66 ± 0.65 pCi/g (<MDC)
Mean[b]	0.17 ± 0.62 pCi/g
Standard deviation	0.74 pCi/g
Mean + 1 standard deviation	0.91 pCi/g

Notes:
a – Error is reported laboratory error of 2 sigma.
b – Error is the mean laboratory error of 25 of the 50 samples.

TABLE 4-2
ELEVATED STRONTIUM-90 SOIL SAMPLES (November 2000)

Sample Location	Concentration (pCi/g)
WWTB area	1.0 ± 0.73
North of main building	2.0 ± 0.70
Under the Decontamination Room concrete floor	4.3 ± 0.62

4.3 FINAL STATUS SURVEY SOIL/LAND AREA EVALUATION

Soil characterization efforts prior to the FSS revealed three localized areas of subsurface soil contamination, which were eventually remediated. These included soil associated with the WWTB, soil under the Cell Operations Area trench, and soil adjacent to leaking drain lines joints under the Service Area floor. Much of the FSS's subsurface soil assessment was patterned to show that soil contamination did not spread from the areas of known soil contamination and the hot cell basement area, which was considered the most likely source of subsurface contamination if unidentified breeches were present.

No surface soil contamination was ever identified during the characterization and FSS work; however, limited contamination was found on the Loading Zone pavement, which is between the main building and the pond. This area was used during D&D operations as a radioactive waste loading and storage area. The localized areas of low-level contamination in this area were easily remediated. No other contaminated areas outside of the facility structures were found. The following provides additional information about the land areas that were considered impacted as part of the FSS.

4.3.1 Waste Water Treatment Building

As part of the remedial effort of the WWTB area (as noted in the previous section), forty cubic yards (yd3) of soil was excavated to depths up to 2.7 meters (9 feet) from the WWTB area and comprehensive soil sampling was performed to confirm that the remedial activities brought soil concentrations to below the release criteria of 5 picocuries per gram (pCi/g).

Underground storage tanks (USTs) 401 A&B and 402 A&B, which were associated with the WWTB process, were also excavated along with related piping. No external contamination was found on any of the pipes or on the exterior of the tanks. In addition, the concrete pad upon which the tanks were set was surveyed with negative results. Since the characterization surveys confirmed the absence of radiological contamination, the area of the USTs was backfilled.

4.3.2 Loading Zone Area

This area between the main facility and the pond includes the soil under the Loading Zone (paved area) and unpaved areas around it. The Loading Zone paved area was surveyed as a Class 1 structure. Low levels of contamination were found in localized, low-lying paved areas at this location. This area was used for loading and storing radioactive waste from the D&D project. This area was also suspect because it lies in the path of storm water runoff flowing from the Reactor Building to the pond. If contamination were to escape from the Hot Cell complex or the Reactor Bay, the contamination would likely migrate towards this area and the pond.

4.3.3 Pond

The pond is located west of the Reactor Bay. The pond sediments (not water) were considered potentially impacted due to the possibility of contamination runoff that could have occurred during facility and waste handling operations.

4.3.4 Parking Lot and Sidewalk

There was a possibility that contamination could have been tracked onto the sidewalk and into the parking lot. The sidewalk leading to the facility appears to be original because of extensive wearing. The parking lot has likely been resurfaced at least once. Soil samples along the edge of the sidewalk and in front of the main administrative area were taken during characterization activities and no elevated levels of radioactivity were identified.

4.3.5 All Exterior Areas Inside the Cyclone Fence

All other land areas located in the cyclone fence were considered potentially impacted for purposes of the FSS.

4.4 FSS SOIL/LAND AREA RESULTS

The DOC collected 154 surface soil samples at a rate of approximately 1 sample per 50 m2. Surface samples were generally taken at a depth of approximately 6 inches. Samples were subjected to Sr-90 analysis and gamma spectroscopy for Co-60. Exposure/dose rates were taken at 3 feet (1 meter) above each soil sampling location. Surface soil samples were often mixed with other samples to form a composite sample to limit the analytical costs. All of the samples were well below 1 pCi/g. If one of the three samples were 5 pCi (soil criteria at the time of the FSS), the resultant composite would measure at least 1.7 pCi/g. As a result, there is high level of confidence that no single soil sample exceeded the release criteria.

4.4.1 Sediment Samples

Sediment samples from the pond were collected at three locations. The pond was considered part of the broader, Class 3 area inside of the fence line, although that area was subjected to a higher sampling rate. One of the samples was taken directly at the facility discharge point. A split spoon was used to collect sediment from about the top 6 inches. Like soil samples, the collected sediment was subjected to gamma spectroscopy and Sr-90 analysis. All samples were less than 1 pCi/g.

4.4.2 Subsurface Sampling

Thirty-five locations throughout and around the facility were subjected to FSS subsurface soil sampling. These samples were taken in the following areas:

- Service Area (5)
- Fan Room (3)
- Finishing Area (location of old Loading Dock) (4)
- WWTB Area (3)
- Loading Zone Area (7)
- Eastern land area of the complex (5)
- Reactor bay (2)
- Pond area near Loading Zone (1)
- Cell Operations (Cell Face) Area (3)
- Administrative Area Near Cell Face (2)

Except for samples in the basement, subsurface samples were taken from 6 inches (15 centimeters) to 10 feet (3 meters) or until bedrock was hit and drilling could go no further. Many of the samples around the hot cell basement (in the Service Area and Cell Operations Area) were taken to depths of 20 feet (6 meters) or until probe refusal. This was done to ensure that migration of contaminants did not occur from the hot cell basement area. Deep samples consisted of a composite of the soil column (0.5'-10' or 10'-20') from the sample location. The samples under the hot cell basement were collected directly beneath the concrete floor. Since the hot cell structure was built directly upon a rock ledge, no soil boring was possible. The limited amount of soil between the basement floor and the ledge was collected for analysis. Sr-90 analysis and gamma spectroscopy analyses were performed on each subsurface sample. All samples were less than 1 pCi/g.

4.4.3 Non-FSS Soil Sampling

In addition to the FSS subsurface samples, a collection of other deep samples were taken that, although not part of the FSS, are indicative of as-left conditions. As mentioned previously, three areas were known to have soil contamination at one time. These areas included soil areas underlying the WWTB, the Cell Operations Trench, and the Service Area.

The soil underlying the WWTB, which had contamination levels up to 580 pCi/g, was remediated to about 9 feet in certain sections. After remediation was complete, 14 subsurface soil samples from various depths and locations were sent to Duke Analytical Laboratories for Sr-90 analysis. The sample results ranged from non-detectable to 3.91 pCi/g.

During excavation of the drain lines under the floor of the Service Area, 17 soil samples were collected along the length of two piping runs. At three locations along the drain lines, contamination of up to 23 pCi/g was identified through laboratory analytical processes. This contamination was believed to have originated from joints that were slightly leaking. These areas were remediated and then soil samples were collected around each remediated area to ensure that no contamination remained. The drain lines extended to about 6 feet below grade. After remediation, soil samples were collected at points in and around the remediated area. Soil was collected from the remediated area to about 10 feet below grade using a hand-held split spoon. Besides the three contaminated locations, the results showed no more than 0.39 pCi/g along the bed of the removed drain lines. After remediation of the three areas, levels in these areas were no more than 2.7 pCi/g.

Finally, excavation of contaminated soil, up to 48 pCi/g Sr-90, was also necessary under the shallow trench that lined the base of the hot cell's operational face (location of the manipulators). This trench apparently had leaked into the underlying soil over time. Remediation was necessary to about 6 feet below grade near the west end of the trench and to a lesser degree along the entire length of the trench. To verify the absence of a contamination plume, sampling was conducted after remediation. This sampling included core boring through the floor adjacent to and north of the trench, and in the Fan Room as part of the FSS. Additionally, subsurface sampling was done directly in the trench at three locations. Some soil sampling results in this area approached but were less than the 5 pCi/g criterion.

4.5 SURFACE WATER AND GROUNDWATER CONTAMINATION

Although surface water and groundwater data are minimal, there is no evidence of surface water or groundwater contamination from radioactive materials at the Quehanna facility.

As part of their site characterization effort, the characterization contractor collected water samples from three locations in 1991 and 1992. The results from these sampling activities are presented in the Table 4-3.

TABLE 4-3
STRONTIUM-90 GROUNDWATER CONCENTRATIONS

Sample Location	Collection Date	Strontium-90 Concentration (pCi/L)
Groundwater well near subsurface waste tanks	8/27/91 6/17/92	< 0.8 < 0.5
Stream 50 meters west of the facility (Reactor Run)	8/15/91 4/22/92	< 0.7 < 0.5
Tap water from residence north of the facility	8/27/91 4/22/92	< 0.8 < 0.5

Site-wide soil characterization also supports the conclusion that the surface waters and groundwater should be considered as non-impacted.

5.0 PROPOSED DECOMMISSIONING ALTERNATIVE

5.1 END-STATE CONDITIONS

At the completion of this Decommissioning Plan, DEP envisions the following conditions:

- All above grade structures and equipment will be removed
- The Reactor Pool, Hot Cell Basement Area (former Fan Room and Pipe Chase Room), and the Gamma Pool will be fractured to allow drainage (Note: These three subgrade openings are heretofore referred to collectively as ground voids)
- All at-grade slab concrete will be removed and placed into the grounds voids, which will subsequently be filled to grade with fill dirt
- The west end of the Reactor Pool will be altered to establish an acceptable slope
- Soil will be placed and graded over the site
- Native grasses will be planted to complete the site restoration

6.0 DOSE MODELING FOR DECOMMISSIONING

The original Decommissioning Plan directed the release of the facility using the criteria in the Regulatory Guide 1.86 for facility surfaces. Limits on soil contamination were provided by the NRC (NRC 1992a). The established release limit for strontium-90 in soil was 5 pCi/g average and 15 pCi/g maximum. Although the NRC has allowed the Quehanna Decommissioning Project to be "grandfathered" in under these established limits, the DEP now wishes to adopt a contemporary approach. This is prudent since the Regulatory Guide 1.86 criteria do not apply to volumetric radioactivity and it is clear that some residual radioactivity in the concrete resides below the surface.

To support the final site disposition at Quehanna, three dose evaluations are necessary with three different source terms. These include the following:

- Residual radioactivity on the surfaces of above-grade structures.
- Residual radioactivity in the concrete that will be used to fill the subgrade ground voids.
- Residual radioactivity in soil.

The first one, surfaces of above-grade structures, will be modeled in a landfill since it is a foregone conclusion that all above-grade structures will be demolished and removed. This is necessary to remove the hazard of the decaying building and to restore the site in a way that is appropriate for the Quehanna Wild Area. The other two pathways will be modeled as if they contribute to dose simultaneously for future site users.

6.1 ABOVE-GRADE STRUCTURES

The above-grade structural materials will be permanently placed into a Pennsylvania landfill. The modeling approach used was in accordance with Pennsylvania BRP draft guidance entitled "Suggested Sampling and Dose Modeling for Radioactive Waste Acceptance at PA Landfills", dated November 1, 2005. In this approach, the debris is mixed in with other landfill material and placed in a cell that is 200' x 200' and 8'. The model also assumes that the landfill is closed and is immediately used by a resident farmer. As a result, all potential exposure pathways were included in the dose model. No credit is taken for fill cover. The results of the modeled scenario run in RESRAD 6.3, which are presented in Attachment A, is 4.277 mrem/yr for each pCi/g in the landfill. The parameters used are provided in Table 6-1 below. In addition, the values and assumptions used to convert levels of volumetric activity into surface activity are provided in Table 6-2.

TABLE 6-1
DOSE ASSESSMENT SUMMARY FOR ABOVE-GRADE STRUCTURAL MATERIALS

RESRAD Pathway	Status	Source
External Gamma	On	n/a
Inhalation	On	n/a
Plant Ingestion	On	n/a
Meat Ingestion	On	n/a
Milk Ingestion	On	n/a
Aquatic Foods	On	n/a
Drinking Water	On	n/a
Soil Ingestion	On	n/a
RESRAD Parameter	**Value**	
Nuclide concentration	Strontium-90 @ 1 pCi/g	See section 6.1
Time since material placement	0 years	No decay time assumed
Area of contaminated zone	3,176 square meters	PADEP BRP draft guidance
Cover depth	0 meters	PADEP BRP draft guidance
Thickness of contaminated zone	2.44 meters	PADEP BRP draft guidance
Length parallel to aquifer	61 meters	PADEP BRP draft guidance
All others	Default	

TABLE 6-2
SUPPORTING CALCULATIONS FOR BUILDING DCGL DEVELOPMENT

Other Necessary Parameters	Value	Units	
specific activity of surfaces	2.50E+05	dpm/100cm2	iterative input to reach dose limit
specific activity of surfaces	2.50E+03	dpm/cm2	conversion
surface area of building	7.50E+04	ft2	Attachment D
surface area of building	6.97E+07	cm2	conversion
total activity of debris	1.74E+11	dpm	Arithmetic product
total activity of debris	7.84E+10	pCi	conversion
volume of disposal cell	3.20E+05	ft3	PADEP BRP draft guidance
volume of disposal cell	9.06E+09	cm3	conversion
density of disposal cell	1.50E+00	g/cm3	RESRAD default
mass of disposal cell	1.36E+10	g	Arithmetic product
specific activity of cell	5.77E+00	pCi/g	Arithmetic product
annual dose	2.47E+01	mrem/yr	conversion based on 4.277 mrem/(pCi/g)

The results of the dose model show that the predominant exposure pathway is the uptake of crop plants and then ingestion of the crop by a resident farmer. This pathway accounts for 92% of the dose.

The identified scenario is not conservative for the following reasons:

- It presumes that the Quehanna structure radioactivity is uniformly distributed through the disposal cell. The issue of heterogeneity, however, should result in the same calculated dose even though some parts of the landfill's surface may contribute more than others.

  The identified scenario is conservative for the following reasons:

  - Over the radioactive life of strontium-90 (half-life of 29 years), it is doubtful that crop farming would be allowed on the landfill.
  - The landfill cover should provide an effective isolation barrier and prevent any crop uptake during the life of the radioactive material.

  The fact that this is a conservative estimate is demonstrated through the calculations and exposure modeling completed as part of NRC Regulatory Guide 1640, entitled "Radiological Assessments for Clearance of Materials from Nuclear Facilities." In NUREG-1640, in evaluating residual radioactivity on scrap steel, for strontium-90, the critical group uses groundwater affected by strontium-90 that has leached from a landfill. In this document, the mean activity-to-dose relationship is given as 2.1 microrem/yr per pCi/g Sr-90. This is more than 3 orders of magnitude smaller than the relationship used in the above scenario for Quehanna scrap.

6.2 FILL CONCRETE

The recontamination event showed that some residual radioactive strontium resides in a limited number of areas below the surface of the concrete slabs and structures. Because of this, the DOC will treat the remaining concrete slab material as potentially having volumetric levels of residual strontium radioactivity. The level of volumetric activity is believed to be very small and suitable for unrestricted release. As noted previously, it is DEP's intention to leave the existing ground voids at Quehanna and fill them with concrete slabs remaining at the site. To evaluate the dose impact from this action, numerous assumptions were made. The primary assumption is that the Commonwealth of Pennsylvania will maintain the Quehanna Wild Area, which is in the Moshannon State Forest, in perpetuity. This assumption is supported by Commonwealth of Pennsylvania code (17 Pa. Code § 27.4) that dictates the restrictions for the use of a Wild Area. As such, the site will only be used for recreational purposes, primarily hunting and hiking. This future use scenario justifies the exclusion of many of the pathways including the drinking water pathway. Since the groundwater pathway is excluded, factors affecting residual radioactivity transport were left at the default RESRAD settings. These factors may not be accurate; however, they have no effect on the results.

The pathways for exposure stem from future recreational use of the area and from eating game that have grazed on affected portions of the site. Table 6-4 provides the modeling parameters in regards to the site's future use.

For the purposes of this dose model, the following items note the assumptions made with respect to the source term:

- The source term includes concrete volumes in the Reactor Pool and the Hot Cell Basement.
- A packing efficiency of 1.4) is assumed (40% more space will be used than the actual volume of the concrete.
- The resulting concrete volumes will be about 782 m^3, as shown in Table 6-3.

TABLE 6-3
CONCRETE VOLUMES

Concrete Source	Volume (m^3)
Concrete Blocks	57
Reactor Bay	58
Admin Area	122
Finishing Area	190
Service Area	14
Removed Concrete Volume (total of above)	441
Removed Concrete Volume as placed (applying 1.4 factor)	617
Hot Cell Basement[1]	165
Total Concrete Volume	782

- Although there are 2 primary ground voids, and hence, source terms, the sources are grouped into a single source term.
- About half of the concrete material will go into each ground void. As such, the average depth is used in the source parameters. This value is 4 meters.
- Since there are not enough affected materials to completely fill the voids, there should be at least 1 meter of freeboard on top of the concrete waste, which will be filled with soil and other non-affected materials. The walls of the Hot Cell Basement, however, will extend to the ground level. For the purposes of the model, it is assumed that the affected debris pile extends to ground level.
- It is assumed that the source term is a single, regular square area with sides of 12.5 meters (156 m^2) and a depth of 4 meters. This volume provides the approximate total volume of the remaining concrete.
- The assumed average density of the emplaced material is 2.2 g/cc.
- The reactor pool concrete remained unaffected and is not included in the volume estimates.

[1] This area is not modified since it will be left as-is; hence, the packing factor is unity.

TABLE 6-4
DOSE ASSESSMENT SUMMARY FOR REMAINING CONCRETE MATERIALS

RESRAD Parameter	Value Used	Default Value	Source
Drinking water pathway	Off	On	There is no dwelling or drinking water well within 5 miles of the site (Scientech 2003).
Milk ingestion	Off	On	There will be no dairy cattle on site.
Plant ingestion	Off	On	No farming will be allowed on site.
Livestock water	0	1	Game on site will only have access to natural surface water.
Irrigation water	0	1	No irrigation is allowed on site.
Area of contaminated zone (m^2)	156.25	10,000	Noted in text.
Thickness of contaminated zone (m)	4	2	Noted in text.
Density of contaminated zone (g/cm3)	2.2	1.5	Noted in text.
Indoor time fraction	0.0	0.5	No dwellings are allowed on site.
Outdoor time fraction	0.019	0.25	Recreational use of site 2 of 52 weeks per year. Half of this time is assumed to be in contact with debris pile.
Livestock fodder intake for meat (kg/d)	3 (game)	68 (livestock)	Per Bob Merrill, District Forester for the Moshannon State Forest District 09 (deer consumption rate of 6-7 pounds per day).
Meat and poultry consumption (kg/y)	31.5	63	Assumes that no more than one-half of an individual's meat diet would be from game originating from or near site.

Table 6-5 below summarizes the principal pathways for the dose modeling of the remaining concrete at the site. The maximum dose occurs directly after closure.

TABLE 6-5
CONCRETE MODELING RESULTS SUMMARY

Pathway	Dose Fraction
Ground (direct radiation)	46%
Inhalation	<1%
Ingestion of affected game	51%
Soil ingestion	2%

The RESRAD 6.3 dose model shows that the primary pathways are direct radiation and ingestion of game animals that have grazed on the site. This is a conservative approach

since the model assumes that game animals are treated as livestock whose feeding area is controlled. In reality, game animals would only derive a very small fraction of their diet from the Quehanna site since they are free to roam and feed throughout the thousands of acres that make up the Moshannon State Forest. The RESRAD program with the developed exposure model predicts that a concentration of 1 pCi/g of strontium-90 in concrete debris remaining at the site would result in a dose of 8.12 E-4 mrem/yr to a hunter that camps on the site and harvests game that has grazed on the site. This value is equivalent to approximately 30,000 pCi/g for a dose of 24 mrem/yr, which is the value specified in 10 CFR 20, Subpart E (License Termination Rule) minus 1 mrem/yr allowed for potential additional exposure from residual radioactivity in soil. As such, the DCGL is 30,000 pCi/g strontium-90 in concrete remaining at the site.

6.3 REMAINING SOIL

The exposure scenario for remaining soil is similar to that used for the remaining concrete. A recreational user is assumed to use the site for 2 weeks of the year and ingests game that has grazed in the affected area. In addition, for this scenario, since the area is considerably larger (7 acres), it is also assumed that the recreational user ingests 1 kilogram of site-grown fodder (presumably berries). The parameters for the RESRAD 6.3 model are shown in Table 6-6 below.

TABLE 6-6
DOSE ASSESSMENT SUMMARY FOR REMAINING SOIL

RESRAD Parameter	Value Used	Default Value	Source
Soil concentration (pCi/g Sr-90)	5	n/a	Previous site soil criteria.
Drinking water pathway	Off	On	There is no dwelling or drinking water well within 5 miles of the site (Scientech 2003).
Milk ingestion	Off	On	There will be no dairy cattle on site.
Livestock water	0	1	Game on site will only have access to natural surface water.
Irrigation water	0	1	No irrigation is allowed on site.
Area of contaminated zone (m2)	28,328	10,000	Equivalent to 7 acres.
Thickness of contaminated zone (m)	6	2	Assumes some affected soil lies beneath hot cell basement, which is about 4 meters deeps.
Length parallel to aquifer (m)	168	100	Assumes area is a regular square.
Indoor time fraction	0.0	0.5	No dwellings are allowed on site.
Outdoor time fraction	0.019	0.25	Recreational use of site 2 of 52 weeks per year. Half of this time is assumed to be in contact with affected soil.
Livestock fodder intake for meat (kg/d)	3 (game)	68 (livestock)	Per Bob Merrill, District Forester for the Moshannon State Forest District 09 (deer consumption rate of 6-7 pounds per day).
Meat and poultry consumption (kg/y)	31.5	63	Assumes that no more than one-half of an individual's meat diet would be from game originating from or near site.

Table 6-7 below summarizes the principal pathways for the dose modeling of remaining soil at the site. The maximum dose occurs directly after closure.

TABLE 6-7
SOIL MODELING RESULTS SUMMARY

Pathway	Dose Fraction
Ingestion of site fodder	30%
Ingestion of affected game	70%

The RESRAD 6.3 dose model shows that the primary pathways for residual radioactivity in the soil are ingestion of site fodder and affected game. Again, this is a conservative approach since the model assumes that game animals are treated as livestock whose feeding area is controlled. In reality, game animals would only derive a very small fraction of their diet from the Quehanna site since they are free to roam and feed

throughout the thousands of acres that make up the Moshannon State Forest. The RESRAD program with the developed exposure model predicts that a concentration of 5 pCi/g of strontium-90 in soil throughout the entire site (both inside and outside the fence line) would result in a dose of 0.38 mrem/yr to a hunter that camps on the site, eats a limited amount of site grown fodder, and harvests and ingests game that has grazed on the site. As such, the DCGL for Sr-90 in soil will remain 5 pCi/g.

7.0 ALARA ANALYSIS

According to Section 1.5 of Appendix D of NUREG-1727, a mathematical cost-benefit ALARA analysis is not required to demonstrate that the ALARA requirement of the current regulation has been met for the unrestricted release alternative described in Section 6.0. The mathematic analysis is not needed and the ALARA requirement will be assumed to be met because (1) in general, loose residual radioactivity on building surfaces, as well as nearly all fixed contamination, has been removed; and (2) large volumes of LLRW have been removed from the site and have been transported to a LLRW disposal facility. Therefore, the decommissioning alternative would meet the ALARA requirement of 10 CFR 20, Subpart E, if directly applicable.

8.0 PLANNED DECOMMISSIONING ACTIVIITES

Section 6.0 provided the general approach proposed for final site closure at Quehanna. The following section provides additional information about the effort necessary to reach the desired end-state. Table 8-1 summarizes the criteria that will be used.

TABLE 8-1
DCGLS

Media	DCGL	Notes
Above grade structures	250,000 dpm/100cm2 Sr-90 total surface contamination	Removable contamination will be controlled to Reg. Guide 1.86 levels – 200 dpm/100cm2
Remaining concrete	30,000 pCi/g	Concrete includes any remaining cinder blocks that will be used as fill
Site Soils	5 pCi/g	

8.1 BUILDING REMOVAL

All of the above-grade structures will be removed to the DCGLs identified in Table 8-1. Contamination surveys conducted as part of the FSS indicated that all surfaces were less than 1,000 dpm/100cm2. After the recontamination event, a few horizontal structures exceeded this value; however, they were far below the current DCGL. In addition, all identified areas that were greater than 1,000 dpm/100cm2 were decontaminated. Extensive surveys have not shown any removable contamination greater than the Regulatory Guide 1.86 criteria for Sr-90, which is 200 dpm/100 cm2.

Since there is a wide gap in the DCGL and conditions that have been reported, all above-grade structures will be surveyed in accordance with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) protocol as Class 3 survey units. If any areas demonstrate removable radioactivity greater than the removable criteria, these areas will be decontaminated and reclassified and surveyed as Class 1 survey units.

8.1.1 Roofing Material Analysis

The roofing material will be cored and analyzed prior to demolition according to the Table 8-2. Cores that are approximately 2" in diameter will be taken of the composite roof layers. Each core will be removed and the layers will be separated to the extent practical. Each layer will then be surveyed, using hand-held instruments. The results of the survey will be documented. No contamination is expected; however, if it is identified, appropriate precautions will be taken during and after the demolition to maintain positive control of any radioactive material.

TABLE 8-2
ROOF SAMPLING

Admin. Area and Finishing Area	3 cores in each (systematic)
Reactor Bay	3 cores near Service Area, 1 core in approximate center of structure
Service Area	9 cores (systematic)

8.2 CONCRETE DISPOSITION

DEP will use concrete originating from within the facility to help fill ground voids. The concrete that will be used to fill the ground voids will come from the areas that include the following: Administration Area and Finishing Area; Reactor Bay; Service Area; and the WWTB (after the above-grade structures have been removed). In addition, the large (10,000 pounds plus) concrete blocks from the hot cell demolition that are currently stored in the parking lot will be used. Through a dose model (Section 6.2), DEP has identified an acceptable DCGL for the remaining concrete. This DCGL will be used to determine if the remaining concrete is radiologically suitable to remain at the Quehanna facility.

8.3 CONCRETE CHARACTERIZATION

The DOC will characterize all concrete that will be used to fill the ground voids. The concrete will be subjected to an onsite screening process. The field technique will use field instrumentation to estimate the activity through direct measurement of drilling spoils. Field measurements will be checked against analyses that will be done at an offsite laboratory. The laboratory process, to be used for at least 5% of the samples, will use wet chemistry to extract and quantify residual strontium activity. If the laboratory analyses do not correlate well with the results of the field analyses, additional laboratory analyses will be employed. The sampling rate for the concrete will be as shown in Table 8-3.

TABLE 8-3
CONCRETE SAMPLING PROTOCOL

Concrete Item	Sampling Protocol	Estimated # Samples
Concrete Slabs	One sample per 64 square meters in areas noted in Section 4.1-4.3. For a 5-inch think concrete slab, this correlates to one sample per 8 cubic meters (m^3).[2]	50
Reactor Pool	Four volumetric samples will be collected of the Reactor Pool base. It is believed that the Reactor Pool contains no volumetric residual radioactivity.	4
Service Area Shield Wall	This shield wall is approximately 2-feet thick. Two samples will be taken of this wall. This correlates to approximately one sample per 8 m^3.	2
Gamma Pool	One sample will be taken in the base of the Gamma Pool. One additional sample will be taken randomly on a wall.	2
Hot Cell Basement	5 Samples will be taken from the base; 10 samples will be taken of the walls; and 5 samples will be taken of the center wall. This correlates to approximately one sample per 8 m^3.	20
Concrete Blocks in Parking Lot	The removed and stored concrete blocks are estimated at 2,000 ft^3. A sample rate of one sample per 8 m^3 equates to approximately 7 samples.	7

Since there will be no exposure pathway to the surfaces of the affected concrete, surface radioactivity characterization will provide little useful information. Potential exposure information will be obtained through the volumetric sampling. As such, DEP will not conduct any further surface characterization on the concrete surfaces except as necessary to maintain control and radiological safety over any remaining residual radioactivity during the demolition and site closure work.

8.4 CONCRETE DEMOLITION AND FILL

The base of the ground voids will first be fractured to allow subsurface water to flow freely from the voids. After the concrete has been sampled and shown to meet the DCGL, it will be broken into manageable pieces and placed into the ground voids. The stored concrete blocks may be placed without further size reduction. Efforts will be made to place first (at greatest depth) the concrete with the highest potential residual radioactivity levels, i.e., from the Service Area. Concrete with a low potential for containing residual radioactivity, e.g., the Administration Area and the Finishing Area, will be placed, as practical, over the higher potential material. Soil will be added as necessary to stabilize the fill material and to minimize voids. The approximate placement and depth of the concrete fill will be documented should this information be necessary to later validate or adjust a dose model. The dose model, however, does not take credit for optimal placement of concrete material.

[2] Note: This sampling density is deemed to be sufficient because of the large difference between the DCGL and actual conditions but is not based on any standard or guidance.

After all of the radiologically impacted concrete is used to fill the ground voids, additional material will be necessary to bring these areas to grade. Remaining structure materials that meet the DCGL, such as cinder blocks, may be used along with soil to completely fill the ground voids.

8.5 FINAL STATUS SURVEY

After all of the structures and slabs have been removed as described, the DOC will initiate a FSS of the remaining surface soil in accordance with the MARSSIM. The FSS will incorporate past shallow and deep sampling, which was done in support of the previous FSS effort. It will also include the comprehensive results of the volumetric concrete sampling. The FSS Report will include a discussion and calculations on exposure to potential future site users.

8.6 ACTIVITY SEQUENCE

The demolition sequence will be coordinated through a demolition contractor. The demolition may take place sequentially or may involve the entire structure in a single comprehensive teardown. The DOC will not allow personnel access into areas that are not structurally sound. Survey will be done before demolition on each section, unless it is unsafe to do so. Slab and structural concrete may be used to fill the ground voids at any time after the concrete sampling has been done and shown to meet the DCGL. The FSS will be initiated after all structures are removed and the ground voids are filled but prior to site restoration activities.

8.7 SITE RESTORATION

After all the ground voids have been filled and a suitable grade is established on the west end of the facility, fill material suitable for planting native flora will be placed over the entire site. Stabilization measures will be taken at the site to minimize erosion. Permanent site stabilization will include placement of clean fill, final site grading, placing of topsoil layer, and seeding.

Vegetated areas shall be considered permanently stabilized when a uniform 70% vegetative cover of erosion resistant perennial species has been achieved, or the disturbed area is covered with an acceptable best management practice (BMP), which permanently minimizes accelerated erosion and sedimentation. Until such time as this standard is achieved, interim stabilization measures and temporary erosion and sediment control BMPs that are used to treat project runoff will be maintained.

8.8 DECOMMISSIONING SCHEDULE

DEP intends to remobilize the decommissioning activities shortly after gaining NRC approval of this plan. All work is currently scheduled to be complete in Calendar Year 2006.

9.0 PROJECT MANAGEMENT AND ORGANIZATION

The DEP has established an administrative and technical organization for management of the decommissioning project that includes the DEP and the DOC. Descriptions of the responsibilities of the DOC project personnel are provided in the following sections.

9.1 RESPONSIBILITES OF PROJECT PERSONNEL

The following section describes the responsibilities of key project personnel and outlines the chain-of-command for site operations.

9.1.1 DOC Project Manager

The DOC Project Manager, who reports directly to the DOC senior management and the DEP, will have overall responsibility for the project. This responsibility encompasses all phases of the project including the on-site and off-site work activities. The Project Manager will be the main contact with the DEP and will be able to meet on short notice to discuss progress, goals and concerns. The Project Manager will be responsible for the management of the project including budgeting, scheduling, staffing, logistics, report preparation and other administrative matters. The Project Manager will also review technical data and ensure that the technical requirements are fulfilled.

The DOC Project Manager will have full stop work authority. The Project Manager also has the authority to make decisions regarding policies and procedures for the operations and activities regarding the Quehanna project. This management approach provides the Project Manager the flexibility and resources necessary for efficient management and decision-making.

9.1.2 DOC Field Services Radiation Safety Officer

The DOC Field Services Radiation Safety Officer (FSRSO), who is a Certified Health Physicist, has overall responsibility for the radiological aspects of the project. The FSRSO will also review technical data and ensure that the technical requirements are fulfilled and valid. The FSRSO will also conduct periodic audits of various on-site activities, procedures, and or records.

9.1.3 DOC Site Supervisor

The Site Supervisor, who reports directly to the Project Manager, will be responsible for the day-to-day on-site activities and decommissioning task management. He will have the authority to make operational decisions and will be responsible for ensuring that the decommissioning activities are performed in the most effective and economical manner while maintaining a safe work environment. The Site Supervisor is responsible for ensuring that the project plans and procedures are implemented. The Site Supervisor is also responsible for conducting the daily safety briefings and previewing the day's planned activities with site personnel. The Site Supervisor will also have full stop work authority.

The Site Supervisor is responsible for maintaining the project log and records. Records to be maintained on site include, but are not limited to, training, medical clearance, respirator fit-testing, dosimetry, survey, sampling, and instrument calibration records.

The Site Supervisor is also responsible for preparing waste shipments and assuring that all packaging, characterization, manifesting, and transportation requirements are met.

9.1.4 DOC Site Radiation Safety Officer

The Site Radiation Safety Officer (SRSO) will be responsible for ensuring that all activities are performed in accordance with the radiological safety requirements as established by the NRC in Title 10 of the Code of Federal Regulations, Part 20 (10 CFR 20). The SRSO, who reports to the Project Manager and the FSRSO, will be responsible for reviewing all project activities and documents that may have a radiological safety impact. The SRSO will ensure that all radiological data collected is complete and in accordance with the procedures. The SRSO will conduct specialized safety briefings when activities are planned, which may have a significant radiological hazard. The SRSO will also have full stop work authority.

9.1.5 DEP Radiation Safety Officer

The DEP RSO will represent the licensee at the work site on a routine basis and reports to the DEP BRP Branch Chief. The DEP RSO, as the RSO listed on the NRC license, ensures that the operations are in accordance with the project documents, NRC regulations, and sound health physics practices. The DEP RSO also has the authority to stop work if it is not being performed in accordance with the Decommissioning Plan or NRC regulations.

9.1.6 Health Physics Technicians

The Health Physics Technicians will be responsible for providing health physics coverage for the decommissioning activities and maintaining the ALARA principles to limit project personnel exposure. They report to the Site Supervisor and the SRSO. They will also perform release surveys for equipment and building materials and the final release survey for the facility. They will also perform the environmental monitoring. Senior Health Physics Technicians will meet the qualifications for ANSI/ANS 3.1 (ANSI 1991).

9.1.7 DEP Bureau of Radiation Protection Staff

This project has the complete support of the DEP. In addition to the DEP RSO, qualified radiological and health physics staff will be available to support the project when needed.

9.2 DECOMMISSIONING TASK MANAGEMENT

Project tasks will be managed through the use of approved procedures and task plans. Task Plans will be approved by the DOC and DEP prior to use. Procedures shall be tracked using the DOC document control procedure. Procedures shall be used when performing tasks in the following areas: employee training, radiation safety, ALARA,

writing RWPs, effluent monitoring, instrument calibrations, personnel monitoring, access control to work areas, sampling and laboratory analysis of samples, environmental monitoring, interim waste storage, transportation and disposal of waste, verification sampling, emergency planning, and other specific operations.

RWPs will be issued for specific tasks within the decommissioning project. The RWPs will describe the specific task involved and include the estimated radiation and dose levels in the work environment, the necessary personnel protective equipment, exposure time limits, and dosimetry requirements. The SRSO will prepare and issue all RWPs. Personnel must read and sign the RWP before performing entering any area covered by the RWP. The SRSO will inform personnel of major changes to an RWP during daily safety briefings and will be required to have all affected personnel read and sign the amended RWP. Each RWP has an expiration date that will be no more than one year from the initiation date.

9.3 TRAINING

Personnel working in radiological controlled areas (RCA) will be trained as radiation workers and will also receive site-specific radiation safety training. The training program will emphasize the nature of the beta, gamma, and x-ray radiation; protection requirements for high-level beta radiation; beta dosimetry; beta measurements; and internal exposure concepts. Training will also include the principles and practices of radiation protection, radioactivity measurements, standardization, monitoring techniques, monitoring instrumentation, and the biological effects of radiation. Furthermore, topics related to specific job tasks will be discussed in daily safety briefings to better prepare personnel for the tasks at hand. Annual refresher training is required for radiation worker qualifications.

The SRSO or Site Supervisor will conduct daily "tailgate" meetings or safety briefings to discuss the work activities of the day. General safety topics will also be discussed to maintain personnel awareness of certain safety issues.

The SRSO will maintain training documents for the DOC personnel during employment and two years after employment. The SRSO will also maintain the training records of on-site project personnel, including non-the DOC personnel.

Visitors to the Quehanna facility and some subcontractor personnel may not be required to obtain radiation safety or U.S. Occupation Safety and Health Administration (OSHA) training to enter an RCA as long as they are escorted by a fully-trained the DOC employee at all times. Visitors are, however, required to read, understand, and sign all appropriate RWPs' before entering an RCA.

9.4 CONTRACTOR SUPPORT

The DOC will be managing and conducting the decommissioning project under contract to the Commonwealth of Pennsylvania. Under certain occasions, the DOC will employ the services of subcontractors to perform specific project tasks or operations. Subcontractors will be directed by the Site Supervisor and will work directly under the DOC's SSHASP, RWPs, and safety and operational procedures as applicable.

Subcontractors will also receive site-specific radiation safety training focusing on the general radiological condition of the site and specific work areas applicable to the subcontractor. All subcontractors will provide a "Commitment of Compliance" by signing site-specific safety documents, RWPs, attending tailgate meetings, and signing other applicable documents. It is the responsibility of the SRSO to obtain the appropriate commitments from the subcontractors.

10.0 HEALTH AND SAFETY PROGRAMS

The DEP and the DOC are all committed to conducting safe operations during this D&D project. This includes using properly trained personnel, limiting radiation exposure, performing work in a safe manner, and operating equipment according to the manufactures' specifications. All work will be conducted under a project specific Health and Safety Plan, which will include task hazard analyses. All radiological work will be conducted under an appropriate radiation work permit, as directed by the DOC's radiation protection program.

11.0 ENVIRONMENTAL MONITORING AND CONTROL

Work at the Quehanna facility will be conducted in a manner as to control releases of airborne or liquid radioactive materials into the environment to levels that are ALARA.

Airborne concentrations of radionuclides will be limited to the effluent concentration limits provided in 10 CFR 20, Appendix B, Table 2. Surface water concentrations should not exceed the EPA's maximum contaminant level (MCL) for drinking water. If either of these limits is exceeded, the DOC will identify the source of the elevated concentrations and take corrective measures to decrease the media concentrations.

12.0 RADIOACTIVE WASTE MANAGEMENT

The DEP expects no radioactive waste to be generated during these final stages of the Quehanna project; however, any materials that do not meet the identified criteria will be handled and disposed of as LLRW at a licensed facility.

13.0 QUALITY ASSURANCE PROGRAM

Decommissioning activities at the Quehanna facility will be performed in accordance with a project specific Quality Assurance Project Plan (QAPP), which will be developed and approved by the DEP and the DOC prior to beginning the final phases of this decommissioning program.

13.1 QUALITY ASSURANCE PROJECT PLAN

The QAPP will be the site-specific quality assurance (QA) document implemented during the course of the D&D project. The QAPP will address such topics as QA coordination, audits, document requirements, equipment maintenance and calibration, data management, and field analysis. Addenda may be added to the QAPP to cover data quality needs, such as QA sampling during the final site-sampling event, that are not addressed in the current version.

The QAPP will provide description and detailed directions on specific quality issues such as:

- Data quality objectives (DQO)
- QA actions to be implemented during the decommissioning project
- Collection, handling, chain of custody preparation, packaging, and shipping of samples
- QA sample requirements
- Data review and approval procedures.

13.2 DOCUMENT CONTROL

All site-specific documents, including this Decommissioning Plan and the QAPP, will be controlled documents maintained on site by the DOC personnel. Off-site management personnel such as the Project Manager and FSRSO will also maintain controlled copies of project-specific documents.

13.3 CONTROL OF MEASURING AND TEST EQUIPMENT

The QAPP will identify requirements for control for measuring and test equipment.

13.4 INDEPENDENT VERIFICATION SURVEY

The NRC may wish to conduct an independent verification survey after the FSS is complete. Alternatively, the NRC may wish to review the FSS as it is being conducted to verify the FSS effort. The DEP will provide the necessary communication and support to the NRC for either effort as it becomes necessary. The DEP will notify the NRC regarding the anticipated schedule of the FSS effort in event the NRC wishes to review the in-progress FSS.

14.0 FUNDING

The Commonwealth of Pennsylvania is providing funding for the Quehanna facility. As such, a standard financial assurance package is not required. However, a new Statement of Intent and a current decommissioning cost estimate are being prepared. This information will be provided to NRC as soon as it is finalized.

15.0 REFERENCES

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ATTACHMENT A

RESRAD Output File for Above Grade Structure Disposal

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Sr-90+D	1.308E-03	1.300E-03	DCF2(1)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Sr-90+D	1.528E-04	1.420E-04	DCF3(1)
D-34	Food transfer factors:			
D-34	Sr-90+D , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(1,1)
D-34	Sr-90+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,2)
D-34	Sr-90+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(1,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Sr-90+D , fish	6.000E+01	6.000E+01	BIOFAC(1,1)
D-5	Sr-90+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
011	Area of contaminated zone (m**2)	3.176E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.440E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	6.100E+01	1.000E+02	---	LCZPAQ
011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Sr-90	1.000E+00	0.000E+00	---	S1(1)
012	Concentration in groundwater (pCi/L): Sr-90	not used	0.000E+00	---	W1(1)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
014	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
015	Number of unsaturated zone strata	1	1	---	NS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Unsat. zone 1, thickness (m)	4.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Sr-90				
R016	Contaminated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.521E-03	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	9.200E+01	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.300E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	5.400E+00	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	5.000E-01	5.000E-01	---	FR9
R018	Contamination fraction of plant food	-1	-1	0.500E+00	FPLANT
R018	Contamination fraction of meat	-1	-1	0.159E+00	FMEAT
R018	Contamination fraction of milk	-1	-1	0.159E+00	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	0.000E+00	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	3176.00 square meters	Sr-90	1.000E+00
Thickness:	2.44 meters		
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	4.277E+00	4.158E+00	3.929E+00	3.222E+00	1.829E+00	2.518E-01	1.285E-03	1.277E-11
M(t):	1.711E-01	1.663E-01	1.572E-01	1.289E-01	7.315E-02	1.007E-02	5.139E-05	5.106E-13

Maximum TDOSE(t): 4.277E+00 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
uclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fra
Sr-90	1.331E-02	0.0031	7.335E-05	0.0000	0.000E+00	0.0000	3.933E+00	0.9194	2.522E-01	0.0590	7.487E-02	0.0175	4.124E-03	0.0
otal	1.331E-02	0.0031	7.335E-05	0.0000	0.000E+00	0.0000	3.933E+00	0.9194	2.522E-01	0.0590	7.487E-02	0.0175	4.124E-03	0.0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathway:	
uclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fra
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.277E+00	1.0
otal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.277E+00	1.0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-	ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄ
Sr-90	1.294E-02	0.0031	7.130E-05	0.0000	0.000E+00	0.0000	3.823E+00	0.9194	2.452E-01	0.0590	7.279E-02	0.0175	4.009E-03	0.0
ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍ
Total	1.294E-02	0.0031	7.130E-05	0.0000	0.000E+00	0.0000	3.823E+00	0.9194	2.452E-01	0.0590	7.279E-02	0.0175	4.009E-03	0.0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathway	
Radio-	ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fra
ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄ
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.158E+00	1.00
ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍ
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.158E+00	1.0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	1.223E-02	0.0031	6.738E-05	0.0000	0.000E+00	0.0000	3.612E+00	0.9194	2.317E-01	0.0590	6.878E-02	0.0175	3.788E-03	0.0C
Total	1.223E-02	0.0031	6.738E-05	0.0000	0.000E+00	0.0000	3.612E+00	0.9194	2.317E-01	0.0590	6.878E-02	0.0175	3.788E-03	0.0C

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways	
uclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.929E+00	1.0C
otal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.929E+00	1.0C

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
Sr-90	1.003E-02	0.0031	5.526E-05	0.0000	0.000E+00	0.0000	2.963E+00	0.9194	1.900E-01	0.0590	5.641E-02	0.0175	3.107E-03	0.0
Total	1.003E-02	0.0031	5.526E-05	0.0000	0.000E+00	0.0000	2.963E+00	0.9194	1.900E-01	0.0590	5.641E-02	0.0175	3.107E-03	0.0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathway	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fra
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.222E+00	1.00
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.222E+00	1.0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄ
r-90	5.692E-03	0.0031	3.136E-05	0.0000	0.000E+00	0.0000	1.681E+00	0.9194	1.078E-01	0.0590	3.201E-02	0.0175	1.763E-03	0.0
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'otal	5.692E-03	0.0031	3.136E-05	0.0000	0.000E+00	0.0000	1.681E+00	0.9194	1.078E-01	0.0590	3.201E-02	0.0175	1.763E-03	0.0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways	
uclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄ
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.829E+00	1.0
*íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	ííí
otal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.829E+00	1.0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	7.838E-04	0.0031	4.318E-06	0.0000	0.000E+00	0.0000	2.315E-01	0.9194	1.485E-02	0.0590	4.408E-03	0.0175	2.428E-04	0.0
Total	7.838E-04	0.0031	4.318E-06	0.0000	0.000E+00	0.0000	2.315E-01	0.9194	1.485E-02	0.0590	4.408E-03	0.0175	2.428E-04	0.0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathwa	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fra
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.518E-01	1.00
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.518E-01	1.0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	2.716E-06	0.0021	1.496E-08	0.0000	0.000E+00	0.0000	8.023E-04	0.6245	5.145E-05	0.0400	1.528E-05	0.0119	8.413E-07	0.0
otal	2.716E-06	0.0021	1.496E-08	0.0000	0.000E+00	0.0000	8.023E-04	0.6245	5.145E-05	0.0400	1.528E-05	0.0119	8.413E-07	0.0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways	
Radio-														
uclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	3.659E-04	0.2848	4.716E-07	0.0004	0.000E+00	0.0000	3.033E-05	0.0236	1.001E-05	0.0078	5.462E-06	0.0043	1.285E-03	1.0
otal	3.659E-04	0.2848	4.716E-07	0.0004	0.000E+00	0.0000	3.033E-05	0.0236	1.001E-05	0.0078	5.462E-06	0.0043	1.285E-03	1.0

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	6.654E-15	0.0005	3.666E-17	0.0000	0.000E+00	0.0000	1.966E-12	0.1540	1.260E-13	0.0099	3.742E-14	0.0029	2.061E-15	0.0
Total	6.654E-15	0.0005	3.666E-17	0.0000	0.000E+00	0.0000	1.966E-12	0.1540	1.260E-13	0.0099	3.742E-14	0.0029	2.061E-15	0.0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathway	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fra
Sr-90	9.434E-12	0.7390	1.216E-14	0.0010	0.000E+00	0.0000	7.821E-13	0.0613	2.584E-13	0.0202	1.409E-13	0.0110	1.277E-11	1.00
Total	9.434E-12	0.7390	1.216E-14	0.0010	0.000E+00	0.0000	7.821E-13	0.0613	2.584E-13	0.0202	1.409E-13	0.0110	1.277E-11	1.0

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Sr-90+D	Sr-90+D	1.000E+00	4.277E+00	4.158E+00	3.929E+00	3.222E+00	1.829E+00	2.518E-01	1.285E-03	1.277E-11

ne DSR includes contributions from associated (half-life ó 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

uclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Sr-90	5.845E+00	6.013E+00	6.363E+00	7.758E+00	1.367E+01	9.929E+01	1.946E+04	1.958E+12

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Sr-90	1.000E+00	0.000E+00	4.277E+00	5.845E+00	4.277E+00	5.845E+00

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ
Sr-90	Sr-90	1.000E+00	4.277E+00	4.158E+00	3.929E+00	3.222E+00	1.829E+00	2.518E-01	1.285E-03	1.277E-11
ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ
Sr-90	Sr-90	1.000E+00	1.000E+00	9.721E-01	9.185E-01	7.533E-01	4.275E-01	5.887E-02	2.040E-04	4.998E-13
ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 2.59 seconds

ATTACHMENT B

RESRAD Output File for Concrete Fill

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Sr-90+D	1.308E-03	1.300E-03	DCF2(1)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Sr-90+D	1.528E-04	1.420E-04	DCF3(1)
D-34	Food transfer factors:			
D-34	Sr-90+D , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(1,1)
D-34	Sr-90+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,2)
D-34	Sr-90+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(1,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Sr-90+D , fish	6.000E+01	6.000E+01	BIOFAC(1,1)
D-5	Sr-90+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
)11	Area of contaminated zone (m**2)	1.562E+02	1.000E+04	---	AREA
)11	Thickness of contaminated zone (m)	4.000E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.250E+01	1.000E+02	---	LCZPAQ
)11	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
)11	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
)11	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
)11	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
)11	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
11	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Sr-90	1.000E+00	0.000E+00	---	S1(1)
R012	Concentration in groundwater (pCi/L): Sr-90	not used	0.000E+00	---	W1(1)
13	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
13	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
13	Density of contaminated zone (g/cm**3)	2.200E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
13	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
13	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	0.000E+00	5.300E+00	---	BCZ
.3	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
3	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
.3	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
3	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
13	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
.3	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
4	Density of saturated zone (g/cm**3)	2.200E+00	1.500E+00	---	DENSAQ
4	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
4	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
4	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
4	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ
4	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
4	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Unsat. zone 1, thickness (m)	4.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Sr-90				
R016	Contaminated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.888E-03	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	1.900E-02	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
018	Meat and poultry consumption (kg/yr)	3.150E+01	6.300E+01	---	DIET(4)
018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
018	Contamination fraction of plant food	not used	-1	---	FPLANT
018	Contamination fraction of meat	-1	-1	0.781E-02	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
019	Livestock fodder intake for meat (kg/day)	3.000E+00	6.800E+01	---	LFI5
019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	0.000E+00	5.000E+01	---	LWI5
19	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
19	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
19	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
19	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
19	Livestock water fraction from ground water	0.000E+00	1.000E+00	---	FGWLW
19	Irrigation fraction from ground water	0.000E+00	1.000E+00	---	FGWIR
9B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
9B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
9B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
9B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
9B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
9B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
9B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
9B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
9B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
9B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	0.000E+00	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	active
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	156.25 square meters	Sr-90	1.000E+00
Thickness:	4.00 meters		
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr

Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	8.120E-04	7.914E-04	7.518E-04	6.280E-04	3.757E-04	6.220E-05	3.650E-07	5.649E-15
M(t):	3.248E-05	3.166E-05	3.007E-05	2.512E-05	1.503E-05	2.488E-06	1.460E-08	2.260E-16

Maximum TDOSE(t): 8.120E-04 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
-90	3.775E-04	0.4649	2.259E-06	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	4.159E-04	0.5122	0.000E+00	0.0000	1.635E-05	0.02
Total	3.775E-04	0.4649	2.259E-06	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	4.159E-04	0.5122	0.000E+00	0.0000	1.635E-05	0.02

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.120E-04	1.00
tal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.120E-04	1.00

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	3.679E-04	0.4649	2.202E-06	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	4.054E-04	0.5122	0.000E+00	0.0000	1.593E-05	0.0
Total	3.679E-04	0.4649	2.202E-06	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	4.054E-04	0.5122	0.000E+00	0.0000	1.593E-05	0.0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathway	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.914E-04	1.000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.914E-04	1.00

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	3.495E-04	0.4649	2.092E-06	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	3.850E-04	0.5122	0.000E+00	0.0000	1.513E-05	0.02
Total	3.495E-04	0.4649	2.092E-06	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	3.850E-04	0.5122	0.000E+00	0.0000	1.513E-05	0.02

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.518E-04	1.00
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.518E-04	1.00

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄ
Sr-90	2.920E-04	0.4649	1.747E-06	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	3.217E-04	0.5122	0.000E+00	0.0000	1.264E-05	0.(
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Total	2.920E-04	0.4649	1.747E-06	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	3.217E-04	0.5122	0.000E+00	0.0000	1.264E-05	0.(

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathway	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fra
ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄ
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.280E-04	1.000
íííííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	ííííí
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.280E-04	1.0(

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fra
r-90	1.747E-04	0.4649	1.045E-06	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	1.924E-04	0.5122	0.000E+00	0.0000	7.563E-06	0.0
Total	1.747E-04	0.4649	1.045E-06	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	1.924E-04	0.5122	0.000E+00	0.0000	7.563E-06	0.0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
r-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.757E-04	1.00
tal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.757E-04	1.00

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	2.892E-05	0.4649	1.731E-07	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	3.186E-05	0.5122	0.000E+00	0.0000	1.252E-06	0.0
Total	2.892E-05	0.4649	1.731E-07	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	3.186E-05	0.5122	0.000E+00	0.0000	1.252E-06	0.0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathway	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.220E-05	1.000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.220E-05	1.00

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
adio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
-90	1.697E-07	0.4649	1.016E-09	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	1.869E-07	0.5122	0.000E+00	0.0000	7.348E-09	0.02
Total	1.697E-07	0.4649	1.016E-09	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	1.869E-07	0.5122	0.000E+00	0.0000	7.348E-09	0.02

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.889E-12	0.0000	0.000E+00	0.0000	3.650E-07	1.00
tal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.889E-12	0.0000	0.000E+00	0.0000	3.650E-07	1.00

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
Sr-90	2.626E-15	0.4649	1.572E-17	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	2.893E-15	0.5122	0.000E+00	0.0000	1.137E-16	0.0
Total	2.626E-15	0.4649	1.572E-17	0.0028	0.000E+00	0.0000	0.000E+00	0.0000	2.893E-15	0.5122	0.000E+00	0.0000	1.137E-16	0.0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathway	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.663E-20	0.0000	0.000E+00	0.0000	5.649E-15	1.000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.663E-20	0.0000	0.000E+00	0.0000	5.649E-15	1.0

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
r-90+D	Sr-90+D	1.000E+00	8.120E-04	7.914E-04	7.518E-04	6.280E-04	3.757E-04	6.220E-05	3.650E-07	5.649E-15

he DSR includes contributions from associated (half-life ó 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Sr-90	3.079E+04	3.159E+04	3.325E+04	3.981E+04	6.654E+04	4.019E+05	6.849E+07	*1.365E+14

t specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Sr-90	1.000E+00	0.000E+00	8.120E-04	3.079E+04	8.120E-04	3.079E+04

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Sr-90	Sr-90	1.000E+00	8.120E-04	7.914E-04	7.518E-04	6.280E-04	3.757E-04	6.220E-05	3.650E-07	5.649E-15

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Sr-90	Sr-90	1.000E+00	1.000E+00	9.746E-01	9.258E-01	7.734E-01	4.627E-01	7.660E-02	4.495E-04	6.956E-12

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 3.28 seconds

ATTACHMENT C

RESRAD Output File for Site Soil

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Sr-90+D	1.308E-03	1.300E-03	DCF2(1)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Sr-90+D	1.528E-04	1.420E-04	DCF3(1)
D-34	Food transfer factors:			
D-34	Sr-90+D , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(1,1)
D-34	Sr-90+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,2)
D-34	Sr-90+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(1,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Sr-90+D , fish	6.000E+01	6.000E+01	BIOFAC(1,1)
D-5	Sr-90+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R 1	Area of contaminated zone (m**2)	2.833E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	6.000E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.680E+02	1.000E+02	---	LCZPAQ
R 1	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R 1	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R 1	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R 1	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R 1	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R 1	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Sr-90	5.000E+00	0.000E+00	---	S1(1)
R 2	Concentration in groundwater (pCi/L): Sr-90	not used	0.000E+00	---	W1(1)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R 3	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R 3	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R 3	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R 3	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R 3	Contaminated zone b parameter	0.000E+00	5.300E+00	---	BCZ
R 3	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R 3	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R 3	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R 3	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R 3	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R 4	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R 4	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
R 4	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R 4	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R 4	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R 4	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R 5	Number of unsaturated zone strata	1	1	---	NS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Unsat. zone 1, thickness (m)	4.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Sr-90				
R016	Contaminated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.844E-03	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	1.900E-02	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R 8	Fruits, vegetables and grain consumption (kg/yr)	1.000E+00	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	0.000E+00	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R 8	Meat and poultry consumption (kg/yr)	3.150E+01	6.300E+01	---	DIET(4)
R 8	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R 8	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R 8	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R 8	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R 8	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R 8	Contamination fraction of plant food	-1	-1	0.500E+00	FPLANT
R 8	Contamination fraction of meat	-1	-1	0.100E+01	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R 9	Livestock fodder intake for meat (kg/day)	3.000E+00	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R 9	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R 9	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R 9	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R 9	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R 9	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R 9	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)
R B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of Cl4	not used	0.000E+00	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	28328.00 square meters	Sr-90	5.000E+00
Thickness:	6.00 meters		
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	3.821E-01	3.724E-01	3.538E-01	2.956E-01	1.770E-01	2.940E-02	2.330E-04	8.383E-12
M(t):	1.528E-02	1.490E-02	1.415E-02	1.183E-02	7.080E-03	1.176E-03	9.318E-06	3.353E-13

Maximum TDOSE(t): 3.821E-01 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
A ÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄ
S__90	2.199E-03	0.0058	1.940E-05	0.0001	0.000E+00	0.0000	1.132E-01	0.2962	2.662E-01	0.6967	0.000E+00	0.0000	5.231E-04	0.001
íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	ííííí
T al	2.199E-03	0.0058	1.940E-05	0.0001	0.000E+00	0.0000	1.132E-01	0.2962	2.662E-01	0.6967	0.000E+00	0.0000	5.231E-04	0.001

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
N lide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
A ÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄ
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.821E-01	1.000
íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	íííííí	íííííííííí	ííííí
T al	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.821E-01	1.000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Sr-90	2.143E-03	0.0058	1.891E-05	0.0001	0.000E+00	0.0000	1.103E-01	0.2962	2.594E-01	0.6967	0.000E+00	0.0000	5.099E-04	0.00
Total	2.143E-03	0.0058	1.891E-05	0.0001	0.000E+00	0.0000	1.103E-01	0.2962	2.594E-01	0.6967	0.000E+00	0.0000	5.099E-04	0.00

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.724E-01	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.724E-01	1.00

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
S 90	2.036E-03	0.0058	1.797E-05	0.0001	0.000E+00	0.0000	1.048E-01	0.2962	2.465E-01	0.6967	0.000E+00	0.0000	4.844E-04	0.001
T al	2.036E-03	0.0058	1.797E-05	0.0001	0.000E+00	0.0000	1.048E-01	0.2962	2.465E-01	0.6967	0.000E+00	0.0000	4.844E-04	0.001

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
N lide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.538E-01	1.000
T al	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.538E-01	1.000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Sr-90	1.701E-03	0.0058	1.501E-05	0.0001	0.000E+00	0.0000	8.755E-02	0.2962	2.060E-01	0.6967	0.000E+00	0.0000	4.048E-04	0.00
Total	1.701E-03	0.0058	1.501E-05	0.0001	0.000E+00	0.0000	8.755E-02	0.2962	2.060E-01	0.6967	0.000E+00	0.0000	4.048E-04	0.00

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.956E-01	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.956E-01	1.000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
A														
S 90	1.019E-03	0.0058	8.990E-06	0.0001	0.000E+00	0.0000	5.242E-02	0.2962	1.233E-01	0.6967	0.000E+00	0.0000	2.423E-04	0.001
T al	1.019E-03	0.0058	8.990E-06	0.0001	0.000E+00	0.0000	5.242E-02	0.2962	1.233E-01	0.6967	0.000E+00	0.0000	2.423E-04	0.001

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
N lide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
A														
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.770E-01	1.000
T al	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.770E-01	1.000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Sr-90	1.692E-04	0.0058	1.493E-06	0.0001	0.000E+00	0.0000	8.706E-03	0.2962	2.048E-02	0.6967	0.000E+00	0.0000	4.025E-05	0.00
Total	1.692E-04	0.0058	1.493E-06	0.0001	0.000E+00	0.0000	8.706E-03	0.2962	2.048E-02	0.6967	0.000E+00	0.0000	4.025E-05	0.00

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.940E-02	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.940E-02	1.00

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
N clide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
Sr-90	1.002E-06	0.0043	8.839E-09	0.0000	0.000E+00	0.0000	5.154E-05	0.2213	1.213E-04	0.5205	0.000E+00	0.0000	2.383E-07	0.001
T al	1.002E-06	0.0043	8.839E-09	0.0000	0.000E+00	0.0000	5.154E-05	0.2213	1.213E-04	0.5205	0.000E+00	0.0000	2.383E-07	0.001

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
N clide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.883E-07	0.0034	5.812E-05	0.2495	0.000E+00	0.0000	2.330E-04	1.000
T al	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.883E-07	0.0034	5.812E-05	0.2495	0.000E+00	0.0000	2.330E-04	1.000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-	ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄ
Sr-90	1.599E-14	0.0019	1.411E-16	0.0000	0.000E+00	0.0000	8.230E-13	0.0982	1.936E-12	0.2309	0.000E+00	0.0000	3.805E-15	0.00
ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ
Total	1.599E-14	0.0019	1.411E-16	0.0000	0.000E+00	0.0000	8.230E-13	0.0982	1.936E-12	0.2309	0.000E+00	0.0000	3.805E-15	0.00

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-	ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract
ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄ
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.497E-14	0.0089	5.529E-12	0.6596	0.000E+00	0.0000	8.383E-12	1.0000
ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.497E-14	0.0089	5.529E-12	0.6596	0.000E+00	0.0000	8.383E-12	1.00

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Sr-90+D	Sr-90+D	1.000E+00	7.641E-02	7.448E-02	7.076E-02	5.913E-02	3.540E-02	5.880E-03	4.659E-05	1.677E-12

T : DSR includes contributions from associated (half-life ó 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Sr-90	3.272E+02	3.357E+02	3.533E+02	4.228E+02	7.062E+02	4.252E+03	5.366E+05	1.491E+13

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Sr-90	5.000E+00	0.000E+00	7.641E-02	3.272E+02	7.641E-02	3.272E+02

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Sr-90	Sr-90	1.000E+00	3.821E-01	3.724E-01	3.538E-01	2.956E-01	1.770E-01	2.940E-02	2.330E-04	8.383E-12

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Sr-90	Sr-90	1.000E+00	5.000E+00	4.873E+00	4.630E+00	3.869E+00	2.316E+00	3.847E-01	2.278E-03	3.637E-11

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 8.52 seconds

ATTACHMENT D

Surface Area/Volume Determination for Above-Grade Structures

		lbs / sq ft	sq ft	Total Lbs
Service Area and Reactor Bay Roof	SA	14.9	4,160	61,780
	Rx Bay	14.9	5,612	83,344
Service Area and Reactor Bay Walls	SA	10.5	9,504	99,766
	Rx Bay	12.0	14,780	177,319
Admin Area and Office Mezz Roof		13.7	7,400	101,380
Admin Area and Office Mezz Walls	Admin	3.6	4,100	14,760
	Off Mezz	3.6	780	2,808
Finishing Room Roof		3.6	13,100	47,160
Finishing Room Walls (Metal)		3.6	8,000	28,800
Boiler Room & Electrical Room Roof		13.7	4,000	54,800
Boiler Room & Electrical Room Walls	BR	2.3	2,058	4,733
	ER	2.3	728	1,674
Pump Room Roof		13.7	768	10,522
Overall Totals			**74,990**	**688,846**

Service Area Walls

Height (ft)	Length (ft)	Width (ft)
36	80	52

(Sample Section of SA Walls)

	Lbs	Lbs/sq foot
4 12" I Beams	24,480	8.5
20 19' 3&1/2" Angle Iron	2052	0.7
Aluminum Siding 3/32"	3700	1.3
Total:	30,232	**10.5**

Reactor Bay Walls (same as above with 1.5 lbs/sq ft for insulation added)

Height (ft)	Length (ft)	Width (ft)	
40	92	46	<---East End

Height (ft)	Length (ft)	Width (ft)	
70	30	46	<---West End

	Lbs/sq foot
Total:	**12.0**

	Square feet	Lbs
Total Wall SA	9504	99765.6
Total Wall Rx Bay	14780	177318.9

Service Area Roof

Length (ft)	Width (ft)
80	52

(Sample Section of SA Roof)

	Lbs	Lbs/sq foot
16 8', 14 4", and 8 55' angle iron trusses	4,800	1.2
4 55' 6" I-beams	6600	1.6
Aluminum Siding 3/32"	5400	1.3
1/2" tar	12480	3.0
1" gravel	32500	7.8
Total:	61,780	**14.9**

Reactor Bay Roof

Length (ft)	Width (ft)
122	46

	Lbs/sq foot
Total:	**14.9**

	Square feet	Lbs
Total Wall SA	4160	61780
Total Wall Rx Bay	5612	83343.6

Admin Area and Office Mezz Roof

Total Area (sq ft) 7400

(Same as SA Roof minus trusses)

	Lbs/sq foot
6" I-beams	1.6
Aluminum Siding 3/32"	1.3
1/2" tar	3.0
1" gravel	7.8
Total:	**13.7**

	Square feet	Lbs
Total	7400	101380

Admin Area and Office Mezzanine Walls

Total Area (sq ft) 4100

(Same as SA Walls with 6" I-beams instead of 12")

	Lbs/sq foot
6" I Beams	1.6
3&1/2" Angle Iron	0.7
Aluminum Siding 3/32"	1.3
Total:	**3.6**

Office Mezzanine Walls

Total Area (sq ft) 780

	Lbs/sq foot
Total:	**3.6**

	Square feel	Lbs
Total Wall Admin Area	4100	14760
Total Wall Office Mezz	780	2808

Finishing Area Roof

Total Area (sq ft)	13100	
		Lbs/sq foot
6" I Beams		1.6
3&1/2" Angle Iron		0.7
Aluminum Siding 3/32"		1.3
	Total:	**3.6**

	Square feet	Lbs
Total Finishing Area Roof	13100	47160

Finishing Area Walls		
Total Area (sq ft)	8000	
		Lbs/sq foot
6" I Beams		1.6
3&1/2" Angle Iron		0.7
Aluminum Siding 3/32"		1.3
	Total:	**3.6**

	Square feet	Lbs
Total Finishing Area Roof	8000	28800

Boiler Room and Electrical Room Roof

Total Area (sq ft) 4000

(Same as SA Roof minus trusses)

	Lbs/sq foot
6" I-beams	1.6
Aluminum Siding 3/32"	1.3
1/2" tar	3.0
1" gravel	7.8
Total:	**13.7**

	Square feet	Lbs
Total	4000	54800

Boiler Room and Electrical Room Walls

Boiler Room

Height (ft)	Length (ft)	Width (ft)
14	35	56

	Lbs/sq foot
6" I Beams	1.6
3&1/2" Angle Iron	0.7
Cinderblock	Not Included
Total:	**2.3**

Electrical Room

Height (ft)	Length (ft)	Width (ft)
14	30	22

	Lbs/sq foot
6" I Beams	1.6
3&1/2" Angle Iron	0.7
Cinderblock	Not Included
Total:	**2.3**

	Square feel	Lbs
Total Wall BR	2058	4733.4
Total Wall ER	728	1674.4

Pump Room Roof

Length (ft)	Width (ft)
48	16

(Same as SA Roof minus trusses)

	Lbs/sq foot
6" I-beams	1.6
Aluminum Siding 3/32"	1.3
1/2" tar	3.0
1" gravel	7.8
Total:	**13.7**

	Square feet	Lbs
Total PR Roof	768	10521.6

Assumptions

SA and Rx Bay roof is 3/32" Al sheeting, 2" insulation, 1/2" tar, and 1" gravel
Gravel is 1.5 g/cm3 (94 lbs/ft3)
6" I-beam is 30 lbs per foot
Density of Insulation is the same as cork - 16 lbs / sq foot
12" I-beam is 170 lbs per foot
4x3.5x1/4 angle iron is 7.7 lbs per foot
Finishing Area Roof and Walls resemble the Admin Area roof and walls
Cinderblock walls still have metal framework

This is to acknowledge the receipt of your letter/application dated

3/9/2006, and to inform you that the initial processing which includes an administrative review has been performed.

AMEND. 37-17860-02

☑ There were no administrative omissions. Your application was assigned to a technical reviewer. Please note that the technical review may identify additional omissions or require additional information.

☐ Please provide to this office within 30 days of your receipt of this card

_____.

A copy of your action has been forwarded to our License Fee & Accounts Receivable Branch, who will contact you separately if there is a fee issue involved.

Your action has been assigned **Mail Control Number** 138549.
When calling to inquire about this action, please refer to this control number.
You may call us on (610) 337-5398, or 337-5260.

NRC FORM 532 (RI)
(6-96)

Sincerely,
Licensing Assistance Team Leader