A Sampling of Actual Decommissioning Case Studies for Review by the Participants in the Workshops that Support the U.S. Nuclear Regulatory Commission's Enhanced Participatory Rulemaking on Radiological Criteria for Decommissioning

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Decommissioning Case Studies

Introduction

The Nuclear Regulatory Commission recently initiated an Enhanced Participatory Rulemaking to develop radiological criteria for decommissioning for NRC- licensed facilities. NRC is enhancing opportunities for participation of affected interests on the rulemaking issues before the NRC staff develops the proposed rule. Consistent with this objective, NRC is conducting a series of workshops to solicit commentary from affected interests on the fundamental approaches and issues that must be addressed in establishing radiological criteria for decommissioning. As announced in the *Federal Register* on _____, the workshops will be held in January through May 1993 at seven locations throughout the United States.

In approving the plan for the Enhanced Participatory Rulemaking to develop Radiological Criteria for Decommissioning, the Commission directed the NRC staff to identify actual cases for review by workshop participants. The Commission intended the cases to include several types of facilities and cover a range of sites. The objective of reviewing the cases with the workshop participants was to illustrate the practical aspects of decommissioning facilities with radiological contamination, including examples of cases where decommissioning was hampered by technical, cost, administrative, or other factors.

This paper presents a suite of six case studies to illustrate "real world" decommissioning experiences and make tangible the abstract concepts, such as radiation dose, risk, and monitoring limitations, that lie at the root of the discussions at the workshops. The case studies represent a range of failities, including a research power reactor, two fuel cycle facilities, two nuclear materials facilities, and a nuclear missile accident site. Two of the facilities primarily involved naturally occurring radioactive materials; the other four involved primarily artificially produced radionuclides. The sites are also distributed geographically in the States of Connecticut, New Hampshire, New Jersey, New York, Oklahoma, South Dakota. The sites are summarized in Table 1.

Although not all of the facilities were licensed under the Atomic Energy Act by NRC or an Agreement State, they all illustrate practical aspects of decommissioning nuclear facilities. Three of the facilities are currently licensed by NRC. One of the facilities was licensed by an Agreement State prior to decommissioning, after which the license was terminated. One site was licensed by an Agreement State, but is currently being remediated under the Environmental Protection Agency's (EPA's) Superfund Program under the Comprehensive Environmental Response,

Compensation, and Liability Act. One of the facilities was not licensed and is being remediated under the Superfund program.

For each case study, NRC staff has assembled summary information that is useful in illustrating decommissioning issues. This information includes a brief descriptions of the facility, nature and extent of contamination, decommissioning criteria, decommissioning approach, current status, and problems encountered. Where appropriate, maps and diagrams have been included to provide the reader with a visual image of the extent and nature of decommissioning action. Although more detailed information is available for each site, the case studies have been intentially kept brief and focused to illustrate generic issues and avoid undue attention during the workshops to individual cases.

Table 1. Summary of Decommissioning Case Studies

Name	Location	Facility Type	Principal Radionuclides	Regulatory Status
UNC-Naval Products	Montville, CT	Fuel Facility	High Enriched Uranium	Active NRC License
Kerr-McGee Cimmaron	Crescent, OK	Fuel Facility	Low Enriched Uranium, Plutonium	Active NRC License
Pathfinder Atomic Power Plant	Sioux Falls, SD	Research Power Reactor	Activation Products (^{60}Co, ^{63}Ni, ^{55}Fe)	Active NRC License
GTE-Sylvania	Manchester, NH	Materials Facility	Thorium	Terminated NH License
Radium Chemical Company	Woodside, NY	Materials Facility	Radium	Terminated NY License; Superfund Site
BOMARC Missile Accident Site	Ocean County, NJ	Nuclear Weapons Site	Plutonium	Superfund Site

The decommissioning case studies follow. Readers with questions should contact Michael Weber, NRC, Mail Stop 5E4, Washington, DC 20555 or (301) 504-1298.

UNC-Naval Products
Septic Leach Field
Montville, CT

Decommissioning Issues

- Technical basis for translating residual contamination into radiological dose and/or risk
- Averaging of residual contamination concentrations over clean soil due to heterogeneous nature of contamination

Facility Description

The United Nuclear Corporation (UNC) Naval Products Facility fabricated nuclear fuel for naval reactors at a facility in Montville, CT. Beginning in 1974, the Montville facility made operational discharges of small concentrations of highly enriched uranium to an onsite septic field as an effluent from the liquid radioactive waste treatment facility. These effluents were discharged in accordance with the license for the UNC-Montville facility. Discharge of enriched uranium to the leach field terminated in November 1987, when NRC authorized discharge of the waste water directly to the sanitary sewer system of Montville, CT, which was acceptable because of the low concentrations of the enriched uranium in the effluent.

In March 1990, UNC announced plans to decommission the Montville facility and terminate their license. UNC-Montville submitted a plan for decommissioning the facility on June 10, 1991. One part of this plan specifically addressed the decommissioning of the formerly used septic leach field. The final revision of the septic leach field decommissioning plan was submitted on May 22, 1992. The site also contains numerous buildings. These are being decommissioned in accordance with the June 10, 1991 decommissioning plan.

Nature and Extent of Contamination

The septic leach field consisted of two parts. Septic field 1 consisted of 43 buried 4-inch diameter perforated pipes of varying lengths, arranged in parallel 2 feet wide by 2.5 feet deep stone-filled trenches, each separated by 5.5 feet of clean soil. Septic field 2 consisted of 2 groups of 6 ten-foot diameter perforated concrete drywells spaced in a polygonal pattern approximately 40 feet apart and each surrounded by 2 feet of crushed rock. The size and orientation of septic leach field 1 is illustrated in Figure 1 and septic leach field 2 in Figure 2. Gross alpha concentrations averaged about 100 pCi/g for samples of the fine-grained material between the stones in the trenches in septic field 1. When averaged over the mass of the stones as well as the fine grained material between the stones, this activity concentration was about 8 pCi/g. Ingrowth of decay products was not significant due to their virtual absence in the original enriched uranium and the limited amount of time since discharge.

Decommissioning Criteria

The major regulatory criteria applied to cleanup of the septic leach field included the following:

1. Option 1 Concentration Criteria from the 1981 NRC Branch Technical Position (BTP) on *Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations* (46 *FR* 52061; October 23, 1981) - 30 pCi/g for enriched uranium.

2. The dose via the groundwater-drinking water pathway was limited to a maximum of 2.3 mrem/yr Total Effective Dose Equivalent (TEDE), consistent with the dose basis for Option 1 concentrations for enriched uranium in NRC's 1981 BTP (in lieu of EPA's proposed drinking water standard of 4 mrem/yr EDE or limit of 20 μg/l for uranium (30 pCi/l)).

UNC proposed a value of $25,000 per person-rem averted be used in calculations to show that residual contamination would be as low as reasonably achievable (ALARA). UNC concluded that the Option 1 criterion in the 1981 BTP is already ALARA for the site. Therefore, no additional effort was necessary to reduce contamination levels below the Option 1 criterion.

Decommissioning Approach

UNC removed, packaged, and shipped for off-site disposal all distribution and service pipes, distribution boxes, sludges, and dryweli cylinders. UNC also removed the residually contaminated materials in excess of the decommissioning criteria described below. UNC verified compliance with the cleanup criteria using a biased survey of the leach field with samples taken every 10 m along the centerline of the exposed trenches. Hotspots were identified and surveyed in a manner consistent with the approach described in NUREG/CR-5849. In determining compliance with the hotspot criteria, the licensee averaged samples along a single horizontal planar surface and not vertically over the trench depths.

To demonstrate compliance with the groundwater protection criteria, the licensee will estimate potential doses to hypothetical future onsite residents, who could consume potentially contaminated groundwater using the RESRAD dose assessment computer code. The modeling done in support of the groundwater pathway assessment assumed that the total activity in the septic field was distributed over the mass of the septic field (including the clean soil between trenches and drywells).

The decommissioning project for the entire leach field cost approximately $2,000,000 dollars and was completed in 12 months. Decommissioning was funded by the Federal government as a result of contractual commitments.

Current Status of Site

The licensee has completed removal of the bulk of the uranium contamination from the septic field. The licensee has also completed its termination survey for the leach field. NRC's contractor has performed a confirmatory survey, but the results of this survey have not been received.

Problems Encountered

The contamination in the leach field existed in a fine grained matrix between or on the 1.5-inch diameter stone used in the leach field. One question encountered was whether or not to allow the stone to constitute part of the mass of the soil samples taken in the field. In response to the licensee's proposal, NRC decided that the stone should be included in the mass of the sample (thus reducing the concentration of each sample) because the fine textured material could not be reasonably separated from the stone when postulating potential doses (like inhalation or direct gamma exposure) from this material.

The licensee at first attempted to correlate gross alpha data from the field to uranium concentrations. This did not work because natural background gross-alpha measurements were too variable. In addition, the chemical form of the uranium in the field did not lend itself to the type of gross alpha analytical technique attempted on these samples. Further, the laboratory chosen by the licensee for analysis of samples was not operating under a proper quality control/quality assurance program. Subsequently, the licensee wasted time, money, and effort trying to evaluate the adequacy of the septic field decommissioning using gross alpha analysis.

Based on this experience, the licensee and NRC learned the following lessons:

- The hotspot criteria in NUREG/CR-5849 are applicable to heterogenous contamination.
- Licensees should complete ALARA analysis in planning decommissioning for various levels of clean-up.
- The adequacy of licensee Quality Assurance/Quality Control programs for radiological sampling should be confirmed by NRC before sampling to ensure that compatible and proper techniques will be used.

Figure 1. Size and Orientation of Septic Leach Field 1

Figure 2. Size and Orientation of Septic Leach Field 2

Kerr-McGee, Cimarron Plants
Crescent, Oklahoma

Decommissioning Issues

- Technical basis for allowing on-site burials of uranium contaminated soils
- Approach to termination of multiple licenses
- Appropriate time period for dose calculations

Facility Description

Kerr-McGee operated two fuel fabrication plants, one for mixed-oxide fuels and one for low-enriched uranium fuels, near Crescent, Oklahoma, between 19__ and 1975. The 1100-acre site is located in a rural part of central Oklahoma, 30 miles north of Oklahoma City, in a farming area. The Cimarron site is listed in the NRC's Site Decommissioning Management Plan.

In addition to the two fuel fabrication plants on the site, the licensee operated several waste-water treatment settling ponds and a burial area (for burials previously allowed under 10 CFR 20.304), which were licensed as part of the uranium plant. Both buildings were contaminated with uranium and plutonium. The settling ponds are contaminated with uranium, while the burial areas (two additional areas recently discovered) contain uranium and trace amounts of thorium from waste disposals associated with offsite activities. Fuel fabrication operations at both plants were terminated in 1975. Major contaminated facilities include the plutonium plant (~26,000 ft^2), the uranium plant (~60,000 ft^2), 3 waste-water treatment settling ponds, and waste burial areas. There were also five previous waste water treatment ponds; these ponds were closed in 1977 and 1978.

Nature and Extent of Contamination

Decontamination of the mixed oxide facility began in 1979, and in 1989, an NRC contractor completed a confirmatory survey that demonstrated that this facility met decommissioning guidelines. No plutonium contamination has been identified outside of the mixed oxide building. The yard outside this facility is contaminated with small concentrations of uranium from the nearby uranium plant. Cimarron Corporation submitted a request for license termination for this facility in August 1990, followed by a request in November 1990 to allow renovations in order to facilitate non-nuclear operations, which NRC approved.

The soil around the uranium plant and the uranium plant building are contaminated with low-enriched uranium (ranging from 2 to 9.1 percent ^{235}U). Soil in the settling ponds and the burial grounds are also contaminated with uranium with concentrations generally in the range of 30 to 100 pCi/g of about 1.3 percent average enrichment. Although a known burial area was exhumed with wastes shipped offsite for disposal, other apparent 10 CFR 20.304 burials have

been discovered at the site and elevated uranium concentrations have been detected in samples taken during the closure of the five former waste water ponds at the site (two additional pits have recently been discovered). The waste water treatment lagoons also contain chemical contamination (primarily nitrate contamination (NO_3)). Groundwater in one area of the site is also contaminated with uranium and non-radiological constituents (e.g., NO_3).

In the top 1 to 2 feet of the ground surrounding the processing buildings, there are about 400,000 ft^3 of soil contaminated with enriched uranium with concentrations averaging 70 pCi/g. Samples from the closed ponds indicate that appreciable portions of the bottoms of two ponds contained contaminated soils in the range of 300 to 400 pCi/g uranium prior to tilling, which occurred at the time of closure of the ponds. Consequently, concentrations of uranium in the bottom sediments would now be expected to be less due to dilution of the contaminated material with clean sediments during tilling.

Decommissioning Criteria

The major regulatory criteria applied during decommissioning include the following:

1. *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material*, July 1982 (An Enclosure to Policy and Guidance Directive FC 83-23)

2. Acceptable Soil Contamination Levels, Enclosure 3 to Policy and Guidance Directive FC 83-23, November 4, 1983

3. Option 2 Concentration Criteria from the 1981 NRC Branch Technical Position (BTP) on *Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations* (46 *FR* 52061; October 23, 1981) -- for enriched uranium, the criterion is 100 pCi/g (soluble), 250 pCi/g (insoluble)

The first group of criteria defined acceptable surface contamination levels on building surfaces; the second group of criteria were applied to the soils surrounding the buildings. The soil criteria were consistent with the criteria in the 1981 BTP and included a value of 25 pCi/g for total plutonium. The BTP was applied to a proposed onsite burial of soil contaminated with uranium in accordance with 10 CFR 20.302.

Decommissioning Approach

Kerr-McGee has finished decontaminating the plutonium plant under an NRC-approved decommissioning plan. At the uranium plant, Kerr-McGee has excavated and shipped for disposal the contents of the initially-identified burial area and has continued decontaminating the building. The licensee has surveyed the soil around the building to detect uranium contamination and submitted a request for authorization (pursuant to 10 CFR 20.3[illegible] to dispose of 400,000 ft^3 of uranium-contaminated soil onsite under Option 2 of the 1981 BTP. Staff has estimated that an on-site disposal would reduce decommissioning costs by

$10 million or more due to the avoidance of costs for disposing of the contaminated soil offsite. The proposed burial also has the advantage of reducing radiation exposure to remediation workers as well as future occupants involved in operating activities at this site. An evaluation of the potential for future groundwater contamination beneath the site concluded that it was unlikely for any uranium to reach groundwater in a well located immediately adjacent to the burial area within 1000 years due primarily to the attenuation of the uranium by the bedrock at the site.

Current Status

- NRC termination of the license for the mixed oxide facility is pending
- Termination of the license for the uranium fuel facility is dependent upon proper completion of the following steps:
  - Adequate site characterization
  - Authorization of onsite disposal in accordance with 10 CFR 20.302
  - Decontamination of the building and adjacent soils in accordance with existing criteria

Problems Encountered

- Limited characterization of the extent and distribution of contaminated material at the site complicated decommissioning
- Prudent measures to reduce the likelihood of human exposure to the contamination and other prescribed conditions on disposal of contaminated soil may be perceived as being inconsistent with the "unrestricted use" standard for decommissioning

Northern States Power
Pathfinder Atomic Power Supply

Decommissioning Issues

- Technical basis for the release of residual contamination containing gamma-emitting radionuclides

Facility Description

The Pathfinder Atomic Power Plant was a 66 Megawatt-electric (~200 Megawatt-thermal) boiling water reactor operated by Northern States Power (NSP) on a site 5.5 miles northeast of Sioux Falls, South Dakota. The plant ceased operations in September 1967, the fuel was removed from the site, and was the facility was placed in Safe Storage (SAFSTOR) in 1971. At that time, NSP decontaminated portions of the facility by minimizing surface activity and filling the reactor vessel with gravel. About 35,000 ft^3 of radioactive Class A low-level radioactive waste were generated in this decontamination effort and shipped offsite for disposal. NSP stored contaminated equipment and piping that was too big to be drummed in the reactor building and spent fuel pool. As a part of the SAFSTOR program, contaminated equipment and material was transferred to a byproduct materials license in August 1972 and the operating reactor license was terminated. NSP installed non-nuclear boilers in the facility and continued until the present to generate electricity using the plants turbine generator.

Nature and Extent of Contamination

Because of Pathfinder's limited operating history (e.g., about 80 days) and lack of any identifiable fuel leaks, radioactive contamination levels were relatively low and caused only by neutron activation. The primary radionuclides were ^{60}Co, ^{63}Ni, and ^{55}Fe; ^{60}Co dominated in terms of radiological significance. Total activity prior to removal of the reactor pressure vessel was about 562 Curies (Ci), all but 0.044 Ci of which was contained in the pressure vessel and its internal hardware. Decommissioning generated about 37,500 ft^3 of waste containing essentially all of the 562 Ci. Figure 1 depicts a cross-section of the reactor and fuel handling buildings. Figures 2 and 3 depict the extent of surface contamination within the reactor and fuel handling buildings, respectively.

Decommissioning Criteria

The criteria used for unrestricted release of the reactor building and fuel handling building were the acceptable surface contamination levels stated in Table 1 of Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors*. The NRC applied an additional criterion that gamma exposure rates measured one meter from the building surfaces shall not exceed 5 $\mu R/hr$ above background.

Decommissioning Approach

NSP initiated final decommissioning activity in the late 1980s. In 1990, NSP removed and shipped the reactor vessel in tact along with other waste to the low-level radioactive waste disposal facility in Richland, Washington by rail and truck. Decommissioning also included partial demolition of the reactor building (the lower portion of the concrete containment structure was buried in place) and decontamination of portions of the fuel handling building. The decommissioning project caused a total estimated exposure to workers of about 60 person-rem and required about one year to complete. Total cost of the decommissioning action was about $16 million.

NSP set action levels for contamination at 80% and 25% of the criteria in Regulatory Guide 1.86 during the radiological survey. Any scan exceeding the criteria triggered additional direct contamination measurements. Those areas exceeding the criteria were decontaminated and resurveyed. Final survey of the site showed that nearly all the areas were remediated to levels less than the "best estimate" of local background radiation.

Some contamination remains in the turbines that are still being used to generate electricity at the plant in conjunction with the non-nuclear boilers. This contaminated equipment will remain at the site under the control of a byproduct materials license until it has been properly removed and disposed of or decays below acceptable contamination criteria.

Current Status

- NRC approved completion of decommissioning in November 1992

Figure 1. Cross-Section of the Reactor and Fuel Handling Buildings (Ref: *Pathfinder Plant Decommissioning Plan*, Northern States Power, 1989)

Figure 2. Contamination survey of the Reactor Building at the Equipment Floor Level (Ref: *Pathfinder Plant Decommissioning Plan*, Northern States Power, 1989)

Figure 3. Contamination survey of the Fuel Handling Building at the Basement Level (Ref: *Pathfinder Plant Decommissioning Plan*, Northern States Power, 1989)

GTE/Sylvania
Manchester, New Hampshire

Decommissioning Issues

- Long-term reliance on institutional controls for limiting exposure to residual radioactive materials

Facility Description

GTE/Sylvania was licensed by the Atomic Energy Commission in 1965 for the use of thorium dioxide in coating electrodes for high-intensity light bulbs. These operations were conducted at a manufacturing plant in an industrial area in Manchester, New Hampshire. The thorium was suspended in methanol and vacuum deposited on the electrodes, which were then cleaned and fired at high temperatures to fuse the coating into a ceramic solid. The electrode was then encapsulated in a gas-tight, fused, silica capsule. GTE/Sylvania continued this process until February 1986, when the facility initiated decommissioning of the thorium operation. The site was licensed by the State of New Hampshire from 1966 until the license was terminated at the conclusion of decommissioning in July 1991.

Nature and Extent of Contamination

Prior to decommissioning, the contamination consisted of processed thorium oxide dust (^{232}Th, ^{228}Th, and some decay products) distributed throughout three rooms (light room, chemistry laboratory, and high temperature furnace room (with two high temperature furnaces)). Other contaminated areas included soil beneath a waste storage area, underground settling tank, and electrical cables and five conduits inside an underground electrical vault. The settling tank was 7.5 feet high with a diameter of about 8 feet and contained about 1 foot of thorium sludge in the bottom. The electrical vault was 5 x 5 x 8 feet and contained about 1.5 feet of thorium sludge on the bottom. Contamination in the settling tank and electrical vault was discovered late in the process of decommissioning; contamination within the electrical vault was not anticipated because it was not involved in the processing or application of the thorium.

About 600 millicuries of thorium was removed during decommissioning; the decommissioning project generated a total of about 3800 ft^3 of low-level radioactive waste, which was sent offsite to a licensed low-level waste disposal facility. Contamination on the surface of the electrical cables three-feet underground feeding the electrical vault was about 22,000 disintegrations per minute (dpm) beta-gamma. After covering with plastic to contain any removable contamination, the surface activity was lowered to about 14,000 dpm. The conduit entrances measured up to 9600 dpm direct beta-gamma. Soils beneath the waste storage area are contaminated with thorium up to 500 pCi/g.

Decommissioning Criteria

The major regulatory criteria applied to cleanup of the GTE/Sylvania included the following:

1. Acceptable surface contamination levels from New Hampshire's "Permissible Levels of Surface Contamination" for 170 dpm/100 cm^2 (removable), 850 dpm/100 cm^2 (average fixed) contamination, and 2450 dpm/100 cm^2 (maximum fixed) surface contamination.

2. Option 4 Concentration Criteria from the 1981 NRC Branch Technical Position (BTP) on *Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations* (46 *FR* 52061; October 23, 1981) - 500 pCi/g for natural thorium.

Decommissioning Approach

When decommissioning of this site began in June 1986, it was expected to be a routine, short-term project. The original goal of the project was to release the site for unrestricted use (i.e., remove and dispose of all thorium contamination to release the site without restriction because of the presence of radioactive material). Decommissioning was significantly complicated, however, by the discovery of the contaminated settlement tank and electrical vault and by reliance on institutional control for the contaminated soil beneath the waste storage area. Most of the excavation and radiological survey work was completed by April 1988. The license for the facility was terminated in July 1991.

Decommissioning activities included the following: a detailed characterization survey; removal and packaging of contaminated equipment; dismantling and packaging of entire section of the plant (two chemistry labs, a hallway, two exterior walls, and roof); removal of High Efficiency Particulate (HEPA) filter; cleanup of waste storage area; removal of over 100 feet of contaminated pipe; decontamination of settling tank and electrical vault; decontamination of two high temperature furnaces; soil sampling, entombment of contaminated soil; shipping all waste to low-level radioactive waste disposal facility; final termination survey; and amendment of property deed placing restrictions on long-term use of the contaminated waste storage area.

The licensee stabilized the contaminated soil in place, posted area markers warning of the radioactive contamination, and placed restrictions in the deed rather than to excavate and dispose of the thorium-contaminated soil in the waste storage area and adjacent to the settling tank. A portion of the contaminated land extends beneath the floor of a machine shop. The licensee argued that removal of the contaminated tank and adjacent soils would have been nearly impossible and would have required the demolition of a load-bearing wall and foundation slab. Such demolition and associated waste disposal would have been prohibitively expensive for the licensee. In response to a technical assistance request from the State of New Hampshire, NRC reviewed the proposal to stabilize the soil *in situ*. Although NRC indicated that it would be more protective and, in the long run, more

economical to remove the contaminated soils during decommissioning, NRC indicated that *in situ* disposal of the thorium-contaminated soils would be acceptable under existing NRC guidance. NRC's 1981 Branch Technical Position (BTP) on *Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations* (46 *FR* 52061; October 23, 1981) allowed disposal of contaminated soils under Option 4 up to 500 pCi/g for natural thorium with appropriate deed restrictions in areas zoned for industrial use only.

Consistent with Option 4 of the 1981 BTP, the licensee amended the deed to prohibit (1) excavation below 1 foot without prior approval and (2) construction or occupation of residential or industrial structures or for agricultural purposes. The restricted area has a surface area of approximately 1.3 million ft^2. The licensee estimated a worst case annual dose to an inadvertent intruder of about 770 mrem whole body dose above background in the event the person disregarded the area markers and deed restrictions and occupied the site of the contaminated soil for about 19 hours per day.

Current Status

- The State of New Hampshire terminated the license for the site on July 30, 1991

Problems Encountered

- Non-radiological hazards (high voltage) and excavation impacts precluded decontamination efforts of the settling tank and electrical vault
- Decommissioning process was hampered by a lack of specific guidance and regulations for acceptable soil contamination limits
- Smaller Agreement State programs may not have sufficient technical expertise to regulate complicated decommissioning projects
- Use of surrogate radionuclide (^{228}Ac for ^{232}Th) in situations where secular equilibrium does not exist needs to be validated on a site-specific basis
- Potential dose in excess of 700 mrem/yr to a site resident after decommissioning is significantly greater than the public dose limit in new radiation protection standards (i.e., 100 mrem/yr) and may be inconsistent with the unrestricted use standard

Radium Chemical Company
Woodside, New York

Decommissioning Issues

- Post-decommissioning recycle or disposal of contaminated building rubble and materials

Facility Description

The Radium Chemical Company site consists of a one-story brick building located in a light industrial section of Woodside, Queens County, New York. The Radium Chemical Company (RCC) produced luminous paint containing ^{226}Ra beginning in 1913 and later manufactured, leased, and sold ^{226}Ra sources to hospitals, medical centers, and research laboratories. The radium sources were stored on-site in lead containers in a poured concrete vault. Following closure of operations in 1983, RCC abandoned the building leaving behind radium sources, contaminated containers and labware, along with building and soil contamination. From 1988 to 1989, EPA undertook limited emergency removal actions under Superfund to secure the facility and remove radioactive sources.

The site was added to the National Priorities List for remediation under Superfund based on a health advisory issued by the Agency for Toxic Substances and Disease Registry in November 1989. The primary current radiological concern involves radium-contaminated building surfaces and components, hazardous wastes, and soil. Present and future potential exposures are primarily associated with direct gamma exposure and exposure via ingestion/inhalation within the facility.

Nature and Extent of Contamination

The one-acre site houses a one-story brick building with a floor area of 10,000 ft^2. RCC leased about 7220 ft^2 of the building. A detailed survey indicated 19 hotspots with elevated dose rate readings, including 15 hotspots in the source vault. A hotspot is defined in this project as an area that measures more than:

(1) 10 mrem/hr at a distance of 1 cm from the surface,

(2) 100,000 disintegrations per minute (dpm) per 100 cm^2 of removable alpha contamination, or

(3) 250,000 dpm per 100 cm^2 removable beta contamination.

The highest hotspot inside the source vault measures 200 mrem/hr at 1 cm. The maximum surface contamination within the source vault was 847,000 dpm/100 cm^2 of removable beta contamination. The highest removable beta contamination outside the source vault was 483,000 dpm/100 cm^2.

Decommissioning Criteria

The objective of the remediation is to reduce contamination to a level that will permit release of the site for unrestricted use without generating an excessive amount of radium waste in the process. The criteria to be applied in this remediation include the following:

(1) EPA's 5 pCi ^{226}Ra/g standard for contaminated soils and materials (based on EPA standards for uranium mill tailings cleanup in 40 CFR Part 192),

(2) EPA's 4 pCi/l action level for ^{222}Rn in indoor air,

(3) Gamma exposure rate no greater than 20 μR/hr above background (based on 40 CFR Part 192 and EPA guidance), and

(4) Acceptable surface contamination levels from NRC's Regulatory Guide 1.86 for removable, and maximum and average surface activity.

Decommissioning Approach

EPA considered 4 alternative remedies to cleanup the contamination at the RCC site, including: (1) no action, (2) total decontamination of the facility (e.g., building surfaces, underground piping, sewer lines, and soil) and disposal of radioactive waste offsite, (3) complete dismantling and removal of the contaminated material and its disposal at a radioactive waste disposal facility, and (4) partial decontamination and dismantling of the facility. EPA selected Alternative 4 with the objective of releasing the site for unrestricted use. This alternative provides the best balance of time for completion, volume of contaminated waste, risk to workers, state and public acceptance, and cost.

EPA will conduct partial decontamination by first removing hot spots contaminated with ^{226}Ra to reduce worker exposure and the risk of spreading contamination during dismantling. Building masonry with ^{226}Ra concentrations less than 5 pCi/g will be disposed of in a sanitary landfill to reduce the volume and cost of waste requiring disposal in a radioactive waste disposal facility. Although the New York State Department of Labor prohibits disposal of wastes containing more than 0.1 pCi/g ^{226}Ra in a sanitary landfill or as *in situ* soil, the agency agreed to waive the requirement due to the technical difficulty in achieving this level.
EPA will then dismantle and remove contaminated material, in sequence, from (1) the building interior; (2) roof, windows, and doors; and (3) residual masonry. Contaminated soil above the criteria will be excavated and prepared for shipment to a disposal facility. EPA plans to ship contaminated material above cleanup criteria to the Envirocare facility in Tooele County, Utah, or acceptable alternative facility.The projected cost to remediate the site is $18,699,000 and will require approximately two years to complete the actions.

Current Status of Site

Problems Encountered

BOMARC Missile Accident Site
McQuire Air Force Base
Ocean County, New Jersey

Decommissioning Issues

- Dependence of preferred remedial action on the availability of affordable waste disposal capacity
- Relationship between the volume of contamination and the cost of the decommissioning action
- Viability of long-term institutional controls to restrict access to contaminated materials

Facility Description

Boeing Michigan Aeronautical Research Center (BOMARC) Missile Site was an active defensive nuclear missile installation from 1958 until 1972. The facility housed missiles equipped with nuclear warheads on a 218 acre site in south-central New Jersey about 18 miles southeast of Trenton (see Figure 1). On June 7, 1960, a fire occurred in one of the onsite shelters housing a missile. The shelter, missile, missile launcher, and warhead were partially consumed by fire. Weapons grade plutonium (WGP) from the nuclear warhead was dispersed to soils and structures in the immediate vicinity of the missile shelter. The material was dispersed by the fire itself as well as the 30,000 gallons of water applied to control the fire for approximately 15 hours. The Air Force reports that no more than 300 grams of WGP was unaccounted for at the time of the accident. Soon after the accident the Air Force fixed the residual contamination in place by applying fixative paint, concrete, and asphalt over the contaminated areas, including the drainage ditch that conducted contaminated runoff during the accident.

The site is being cleaned up under the Superfund program. The Air Force and the Environmental Protection Agency signed a Record of Decision selecting the preferred remedial action in November 1992.

Nature and Extent of Contamination

No concentrations of radionuclides attributable to the missile accident were detected in groundwater, surface water, or air at the site. The contaminants of concern (^{239}Pu and ^{241}Am) have been detected in numerous radiological surveys in site soils, sediments, missing missile launcher, and structural materials at the site. ^{240}Pu, ^{241}Pu, and ^{238}Pu will also be present, but at less significant concentrations. The contamination in the soil appears to be limited to the uppermost foot of soil and is concentrated in discrete "hot spots." The soil contamination does not appear to have migrated vertically downward more than a few inches since the accident. Surface activity surveys of the missile shelter and utility bunkers indicated alpha surface activities up to 80,000 counts per minute per 100 cm^2. Cores through the concrete floor of the missile shelter indicate plutonium levels within the concrete as high as 65 μCi/sample. About 208,000 ft^3 of contaminated soil and material is estimated to be above the applicable cleanup criteria, although additional

material may be discovered during the course of excavation and remediation (see Figure 2). For example, the missing missile launcher and shelter doors may have been disposed of onsite and would likely be removed during remediation.

Decommissioning Criteria

The Air Force developed a site-specific cleanup standard for Pu in soil assuming that people may live on the site at some time in the future. The cleanup standard of 8 pCi/g of ^{239}Pu was calculated using the computer code RESRAD based upon a lifetime risk objective of 10^{-4} cancer risk consistent with current EPA guidance for the Superfund program. The Air Force also proposes to apply the criteria for acceptable surface activity from NRC's Regulatory Guide 1.86 for remediation of the missile shelter, utility bunker, and other structures contaminated on their exterior surfaces. For alpha contamination, these criteria would be <20 dpm/100 cm^2 removable activity, <300 dpm/100 cm^2 maximum fixed activity, and <100 dpm/100 cm^2 average fixed activity.

Decommissioning Approach

The Air Force considered five alternative remedial actions for the contamination: (1) unrestricted access, (2) institutional control, (3) institutional control with removal of specific materials (e.g., missile launcher), (3) onsite treatment of soils and structures and disposed of contaminated material off site in a radioactive waste disposal facility, and (5) removal of all contaminated material above criteria for offsite disposal at a radioactive waste disposal facility. The Air Force selected Alternative #5 (Offsite disposal) because it was cost-effective, permanent, and environmentally preferred. This alternative includes

- Excavation of contaminated soils containing greater than 8 pCi/g of Pu
- Excavation and sectioning of contaminated portions of the concrete apron, utility bunkers, and missile shelter
- Excavation and removal (if found) of the missile launcher
- Containerization, transport, and disposal of contaminated materials in an off-site radioactive waste disposal facility operated by the Department of Energy (DOE)
- Restoration of the site by backfilling with clean fill, grading, and revegetation.

The cost of the preferred remedial action is $7 million if disposal is allowed at a DOE disposal facility; commercial disposal would increase the cost to at least $24 million.

The Air Force's selection of the preferred alternative is contingent on its cost-effectiveness. If it becomes no longer cost-effective, the Air Force

proposes to retain institutional control over the contaminated area, thereby eliminating the only significant route of exposure. This alternative includes monitoring, maintenance, and access control actions currently being conducted at the site.

Current Status of Site

The Air Force is presently continuing to monitor the site and restrict access to contaminated portions awaiting resolution of the issues associated with waste disposal.

Problems Encountered

- Limited availability of disposal capacity for low-level radioactive waste after January 1, 1993 and lack of DOE consent to accept waste for disposal has delayed initiation of the remedial action
- Multiple regulatory reviews by government agencies and the public resulted in late-stage comments that could not reasonably be resolved without delaying the project
- Lack of acceptable cleanup criteria for plutonium delayed progress in remediation until the Air Force developed and negotiated a criterion with State and Federal agencies
- The State disagreed with the Federal agencies (Air Force and EPA) on acceptable risk basis for developing the cleanup criterion for Pu; the State preferred 10^{-6}, while the Federal agencies preferred a cleanup standard based on 10^{-4} lifetime risk. Another group, the Pinelands Commission, asserts that the cleanup criterion should be background, unless the Air Force can demonstrate no adverse impacts on surface water or groundwater quality

Figure 1. Location of the BOMARC Missile Site (Reference: *Record of Decision: BOMARC Missile Accident Site, McQuire Air Force Base, New Jersey*, U.S. Air Force, November 1992, pg. 15)

Figure 2. Extent of Radiological Contamination at the BOMARC Site (Reference: *Record of Decision: BOMARC Missile Accident Site, McQuire Air Force Base, New Jersey*, U.S. Air Force, November 1992, pg. 32)