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This document presents the selected final remedial action for the radioactive wastes at the BOMARC Missile Site, McGuire Air Force Base, New Jersey. The BOMARC Missile Site became contaminated in 1960 as the result of a fire which partially consumed a nuclear warhead-equipped BOMARC missile. The Air Force has decided to pursue excavation and Off-site Disposal of contaminated waste at a Department of Energy (DOE) disposal facility. This is a cost effective, permanent remedy, and is the environmentally preferred alternative. However, should the Air Force be denied the use of a DOE facility, or if other events should dramatically decrease the cost effectiveness of this remedy, then as an interim remedy, the Air Force will maintain the BOMARC Missile Site in accordance with the NEPA No Action Alternative.

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# RECORD OF DECISION

## BOMARC MISSILE ACCIDENT SITE
## MCGUIRE AIR FORCE BASE, NEW JERSEY

MCGUIRE AIR FORCE BASE

UNITED STATES AIR FORCE



November 1992

# DECLARATION OF THE RECORD OF DECISION

### *Site Name and Location*

Boeing Michigan Aeronautical Research Center (BOMARC) Missile Accident Site

McGuire Air Force Base (AFB), Plumsted Township, Ocean County, New Jersey

### *Statement of Basis and Purpose*

This decision document presents the selected final remedial action for radioactive wastes at the BOMARC Missile Accident Site, McGuire AFB, New Jersey. The Air Force developed this Record of Decision (ROD) in accordance with the Council on Environmental Quality (CEQ) Regulations, 40 CFR 1505.2, and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on information contained in the Environmental Impact Statement (EIS) filed with the U.S. Environmental Protection Agency (EPA) on May 22, 1992, the Remedial Investigation/Feasibility Study (RI/FS) dated May 1992, and the administrative record for the BOMARC Missile Accident Site.

### *Assessment of the Site*

The potential release of radioactive substances from the BOMARC Missile Accident site is unlikely. The site poses a minimal risk to public health, welfare or the environment.

*Alternatives*

The five alternatives were evaluated in detail and include:

- **Unrestricted Access:** This alternative was evaluated because it represented a hypothetical worst case where control of the site is assumed to be lost in the distant future. Radioactive contamination would potentially be of concern in the future due to the long half-life of plutonium 239 (24,400 years). If unrestricted access were to occur, contaminated materials would be left as they are. Current management practices including access controls, monitoring, and maintenance would not occur. No remedial cleanup measures would be implemented.

- **National Environmental Policy Act (NEPA) No Action:** If this alternative were implemented, current management practices would continue. These practices include access restrictions, maintenance of existing containment structures, and monitoring of site conditions.

- **Limited Action:** If this alternative were implemented, current management practices would continue. These practices include access restrictions, maintenance of existing containment structures, and monitoring of site conditions. A limited amount of the materials at the site, specifically the missing missile launcher, would be searched for and removed, if located.

- **On-site Treatment:** If this alternative were implemented, radioactive contaminants from soils and structures including the missile launcher and miscellaneous shelter debris, if located, would be removed through on-site physical treatment processes and disposal of in an appropriate, off-site radioactive waste disposal facility.

- **Off-site Disposal:** This is the alternative identified as the preferred alternative. Implementation of this alternative would involve removal of contaminated soils and structural materials including the missile launcher and miscellaneous shelter debris. The contaminated materials would be removed from the site and disposed in an appropriate, off-site radioactive waste disposal facility.

### *Decision*

I have decided to pursue excavation and Off-site Disposal of contaminated waste at a Department of Energy (DOE) disposal facility. This is a cost-effective, permanent remedy, and it is the environmentally preferred alternative. I have also decided that if the Air Force is denied the use of a DOE facility, or if other events should dramatically decrease the cost effectiveness of this remedy, then as an interim remedy, the Air Force will maintain the BOMARC site in accordance with the NEPA No Action Alternative. To ensure that the interim implementation of the NEPA No Action Alternative does not pose any threat to human health and the environment, additional mitigation measures beyond those specified in the EIS and RI/FS will be incorporated. Those measures are listed in the description of the selected remedy and in the Responsiveness Summary.

### *Rationale*

Many factors have been considered in reaching this decision, and have affected the Air Force's ability to proceed with cleanup of the BOMARC Missile Accident Site. The most significant constraints on cleanup at the BOMARC site are the lack of available disposal sites for radioactive wastes, the regulations governing radioactive waste disposal, and the costs associated with radioactive waste disposal. There are only four commercial sites that currently accept low level radioactive waste. Provisions of the Low Level Radioactive Waste Policy Amendments Act (LLRWPAA), which take effect on January 1, 1993 will probably prohibit Air Force access to these commercially-operated disposal sites. The only alternative disposal sites would appear to be those operated by the DOE. DOE has not currently consented to accept the waste at any of their sites, although we are working with them in this regard.

Another factor that has complicated the decision-making process is the unique nature of the project. Documentation for this project was prepared concurrently for both the NEPA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund). This is the first project undertaken by the Air Force to address both regulatory programs simultaneously. The overlapping requirements of the regulatory programs and the degree of regulatory oversight resulted in a process where there were multiple opportunities for agency and public involvement. A substantial effort was undertaken to address the concerns of the U.S. EPA and the New Jersey Department of Environmental Protection and Energy (NJDEPE) and interested members of the public.

Another unique factor associated with this project is the nature of the contaminant. Plutonium contamination engenders an emotional reaction in the public. Because of the unique nature of a plutonium-contaminated site there are no established precedents available to regulatory agencies to guide their oversight. In recognition of the unique nature of the site, the U.S. Air Force (Air Force) carefully considered all possible options and stayed in close coordination with the U.S. EPA and the State of New Jersey. The Air Force provided multiple opportunities for U.S. EPA, NJDEPE, and the public to review and concur during the CERCLA and NEPA process.

The Air Force made an extraordinary effort to explain its actions, obtain concurrence with its plans, and answer inquiries. Because of that effort, the Air Force is not receptive to comments on the Public Plan that would require additional groundwater monitoring or would change the cleanup level that was negotiated with NJDEPE and U.S. EPA. The Air Force originally solicited and received input from the NJDEPE and the U.S. EPA on the scope of groundwater investigations to be completed back in April of 1989. NJDEPE and U.S. EPA made several recommendations, all of which were implemented by the Air Force. The result of these investigations indicated that no plutonium was present in groundwater at the site. A meeting was held to resolve all regulatory comments on the Draft Environmental Impact Statement (DEIS). At the meeting, the Air Force solicited NJDEPE and U.S. EPA for further comments on the issue of groundwater monitoring and no comments were received. However over six months later we received NJDEPE comments on our proposed plan indicating the need for additional groundwater monitoring. The Air Force with U.S. EPA concurrence, firmly believes that we have taken all reasonable actions necessary to characterize groundwater at the BOMARC Missile Accident Site, and to date, we have not detected plutonium in the groundwater. We believe that additional groundwater monitoring would not add to our knowledge of the site and would delay our primary goal to move ahead with the BOMARC Missile Accident Site cleanup.

The determination of an appropriate cleanup level is often a problem in site cleanup. Since there are no applicable cleanup standards for plutonium in soil, the Air Force was faced with the formidable task of developing our own standard. There is no universally accepted method for making this determination, and little consensus among experts on how to go about the process. Without agreement on how clean the site should be, there could be little agreement on how to clean up the site. The Air Force chose a very conservative course of action - we proposed to clean the site to a condition that would allow people to establish residence in the middle of the site for 70 years, and not be affected. The approach for determining the cleanup level was developed through conversation with NJDEPE and U.S. EPA in response to comments provided on the Draft RI/FS and EIS. The Air Force discussed its proposed cleanup levels with NJDEPE and U.S. EPA at a meeting held in January 1992. Based on those discussions, the Air Force prepared a written summation which outlined the agreed upon cleanup level and summarized other decisions reached during that meeting. NJDEPE, however, in their comments during the Public Meeting in June and in their written comments on the proposed plan, and the Draft Record of decision have proposed a new cleanup level which would substantially increase costs while providing insignificant additional risk reduction to the public. The Air Force has established a cleanup level based upon a $10^{-4}$ (1 in 10,000) excess cancer risk. The U.S. EPA concurs with this cleanup level. The NJDEPE asserts that a cleanup level based on $10^{-6}$ (1 in 1,000,000) should be established. The NJDEPE has proposed regulations which would require that this standard be met. However, the proposed rule has not been promulgated as final. The proposed rule cannot be considered as an ARAR. Additionally, in comments the Pinelands

Commission submitted in November 1992 on the Draft Record of Decision, they stated that their Comprehensive Management Plan calls for cleanup to background levels unless it is demonstrated that treatment to a different level will not degrade or impact the surface or groundwater quality. However, treatment to background levels is not required under CERCLA or the NCP, particularly in circumstances where such cleanup levels are not necessary to protect human health and the environment. We also note the ground and surface water sampling conducted during the remedial investigation did not detect weapons grade plutonium in filtered samples from either media. It will be even more certain that a plausible potential risk of contamination migration into either media does not exist after the currently contaminated soil is remediated as proposed in this Record of Decision. The Air Force's proposed cleanup level is protective of human health and the environment.

The Air Force must balance its commitment to environmental restoration with our responsibility to judiciously manage limited financial resources. This is why the Air Force has retained the option to implement the NEPA No Action Alternative as an interim measure. Preliminary estimates of the disposal costs at commercial facilities, even if they were available, were found to be two or three times the cost of disposal at a DOE facility. The cost of excavating the site to achieve the cleanup level now proposed by the NJDEPE, could double the cost of the Off-site Disposal Alternative. It is also possible that disposal costs at a DOE facility could dramatically escalate for unforeseen reasons. Under any of these circumstances the cost effectiveness of the Off-site Disposal Alternative would be lost, and the Air Force would implement the No Action Alternative as an interim remedy. The Air Force must direct its limited financial resources to ensure that costs associated with individual site cleanups do not jeopardize our ability to focus financial resources on the sites that pose the greatest threat to the human health and the environment.

*Description of the Selected Remedy*

The major components of the selected remedy include:

- Excavation of source soils containing greater than 8 picocuries per gram (pCi/g) of plutonium. This will limit maximum risk to any future resident of the site to a level on the order of one in 10,000 excess cancer risk, a level considered acceptable by U.S. EPA.

- Excavation and sectioning of contaminated portions of the concrete apron, utility bunkers and the missile shelter.

- Excavation and removal (if found) of the missile launcher.

- Containerization, transport, and disposal of radioactive materials in an off-site facility designed for long-term management of radioactive materials.

- Restoration of the site by back filling with clean fill as needed, followed by grading and revegetation of the site with indigenous plant species.

In addition, strict engineering controls will be applied during the excavation phase to prevent any possible exposures to workers or to off-site populations. These include dust suppression, and runoff/sedimentation control measures.

Remedial action is not necessary for the management of off-site migration of radioactive contaminants. It has been determined that off-site migration of radioactive contaminants does not pose an unacceptable risk to human health or the environment, as defined by the NCP. The selected remedy for the BOMARC Missile Accident Site addresses source control (remediation of on-site contaminant sources) of radioactive wastes in order to eliminate or reduce the risks posed by the site to levels that are protective of human health and the environment. Contamination of the site by non-radioactive wastes is the subject of an ongoing RI/FS of McGuire AFB.

The selection of the preferred alternative is contingent on the condition that Off-site Disposal will remain cost-effective. Preliminary cost estimates documented in the RI/FS indicate that Off-site Disposal at a U.S. DOE disposal facility would be cost-effective. If the DOE refuses to accept the BOMARC waste or if regulatory actions by other Federal or State agencies delay the Air Force initiation of the preferred alternative or substantially increase the volume of material to be excavated, the Air Force will reevaluate the cost reasonableness of implementing the preferred alternative. Should these costs increase to the point that in our judgement, Off-site Disposal is no longer cost-effective, then the NEPA No Action Alternative would be implemented.

The Off-site Disposal at a DOE facility, at this time, appears to be cost-effective and provides overall effectiveness proportionate to its costs and duration for remediation of radioactive contaminants. The NEPA No Action remedy is also cost effective and affords the Air Force an interim remedy should implementation of Off-site Disposal Alternative lose its cost effectiveness. The Air Force with U.S. EPA concurrence feels comfortable with the NEPA No Action Alternative as an interim solution. There are no overriding health risks associated with this alternative as borne out by the EIS. However, given regulatory requirements such as CERCLA and the Air Force's desire to limit risk to human health and the environment, off-site disposal is still the preferred alternative.

The Air Force must continue to balance limited resources with its commitment to environmental restoration. While off-site disposal at a DOE disposal site at an estimated cost of $7 million is acceptable, a cost in excess of $24 million for disposal at a commercial facility does not pass the cost effectiveness test. While the overall effectiveness of the remedy would remain, the cost, having tripled, would no longer be proportional to the overall effectiveness. Currently Congress has appropriated $400 million in Defense Environmental Restoration Account (DERA) funds for FY 93. An additional $108 million is required for other must pay requirements. Cleanup of the BOMARC Missile Accident Site must compete for this limited funding with other DERA projects. With no imminent risk to human health or the environment the $7 million can be justified while the $24 million cannot.

The NEPA No Action Alternative is protective of human health and the environment in that it eliminates the only exposure scenario that presents risk -on site exposure- for as long as the Air Force maintains control of the site. This alternative includes all monitoring, maintenance, and access control actions currently implemented at the site. Current site activities include:

- Restriction of public access to the site
- Prevention of deterioration of existing containment structures
- Characterization of the culvert
- Monitoring of distribution and potential migration of plutonium and americium on-site and off-site including the ponding area adjacent to Route 539 and the culvert below the road. Based on the sampling results, appropriate measures will be implemented to restrict the potential airborne transportation of contamination
- Prevention of disturbance of the site

These goals would be accomplished through implementation of the following actions:

- Installation and maintenance of appropriate interim remedial measures, including fencing and capping of the ponded area (if deemed necessary by monitoring results)
- Monthly visual inspections
- Maintenance of concrete apron
- Annual radiological surveys
- Maintaining government control of the site.

*Statutory Determinations*

The selected remedy is protective of human health and the environment and complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action. The Off-site Disposal remedy utilizes permanent solutions to the maximum extent practicable. The remedy does not satisfy the statutory preference for treatment and reduction as a principal element. Waste and site conditions make treatment and volume reduction problematic. The Off-site Disposal remedy will result in the excavation removal of radioactive substances, therefore, radiological surveys or further evaluation of the site would not be required. The NEPA No Action Alternative is a cost-effective interim remedy if a DOE disposal facility is not available. NEPA No Action is protective of the human health and the environment. The interim remedy (NEPA No Action) also complies with Federal and State requirements that are applicable, relevant, and appropriate. The interim remedy does not satisfy the preference for treatment that reduces toxicity mobility or volume of the waste, or remove radioactive materials to acceptable health-based risk levels. Therefore, this interim remedy would require radiological surveys and reevaluation at 5 year intervals.

*Mitigation*

Although some of the mitigation measures are legal requirements, they are all consistent with the Air Force's desire to remediate the BOMARC Missile Accident Site safely and with the highest degree of protection to the public and the environment. The Air Force will develop mitigation plans that will be incorporated into the remedial design specifications developed prior to the remedial action. A general outline of the mitigations associated with the selected remedy are provided below:

- All active exposed piles of soil and debris would be watered and covered when not in active use.

- The excavated area would be replaced with clean fill, compacted to original grade, covered with topsoil (as needed), and replanted with locally indigenous flora as soon as feasible.

- Perimeter control measures including construction of silt fences, berms, diversion ditches, sediment traps, and retention basins would be used: activities would be staged to minimize the area of exposed soils during remedial activities and the potential for detachment and off-site transport of contaminated materials.

- Areas of the site which contain the two New Jersey threatened plant species would be protected with fencing or other barriers from site activities and other site disturbances associated with launcher removal activities which could destroy these plant species.

- An outside decontamination pad would be used for decontamination of heavy equipment. Water produced from the decontamination process would be filtered and recycled in order to minimize generation of waste water requiring disposal. All waste water from decontamination would be collected and containerized for proper off-site disposal.

- Surface water sampling would be conducted during rainfall run off events, in order to ensure that contaminated sediments are not leaving the site via the surface water pathway.

- Truck movements would not, to the extent possible, occur during peak commuting hours, and would be reasonably distributed throughout the day.

- Prior to beginning excavation, a Health and Safety Plan (H&SP) would be written to establish standard protective measures and procedures to be taken by on-site personnel. The H&SP would set strict standards for controls on wastes generated by on-site remedial activities. This plan would be strictly enforced by an on-site Certified Health Physicist who would monitor all remedial activities. This plan would identify respiratory protective equipment and safety garments to be utilized by site personnel, identify requirements of a bioassay and dosimetry program, and establish strict site entrance and exit procedures. The site entrance and exit provisions would include:

- A facility to decontaminate personnel who may be contaminated during the course of work.

- A facility to decontaminate equipment and transport vehicles before they leave the site.

- A convention in which all protective garment would remain on-site after use, and would be disposed of as potential radioactive waste in a licensed facility.

- A thorough scanning of all vehicles, equipment, and personnel prior to leaving the site at any time to prevent transport of radioactive materials off-site.

• On-site sectioning of concrete would be performed out of necessity outdoors. Strict engineering controls designed to prevent resuspension of contaminated particulates would be implemented. The concrete would be sectioned into manageable-sized pieces, and the layer of asphalt beneath the concrete would be removed. All water and fluids resulting for lubricating or cooling the sectioning equipment would be collected through a vacuum process and vented through a high-efficiency particulate air (HEPA) filter to capture particulate contaminants.

- Air samplers would be placed to monitor sectioning activities. If dust or airborne contaminants are generated, a separate vacuum blower would also be used to vent the air through a HEPA filter.

The Air Force would implement the following mitigations associated with the NEPA No Action remedy:

- During fence installation activities, dirt roads, exposed storage piles, and off-road areas would be watered on an as-needed basis. Activities would be curtailed during high-wind conditions.

- Appropriate radiological protocols would be used to ensure that controls are implemented to keep occupational doses within regulatory limits and as low as reasonably achievable (ALARA).

*Conclusion*

The Air Force has analyzed and evaluated the environmental impacts along with the costs and benefits of proceeding with the remedial action for the BOMARC Missile Accident Site. Following a review of the EIS, RI/FS, and the Administrative Record for the BOMARC Missile Site, I have adopted the remedial actions described above. This document and the supporting EIS fulfill the requirements of NCP, NEPA, the CEQ Regulations, and AFR 19-2.

**Date:** Nov 16, 1992 **Signature:** Gary D. Vest

GARY D. VEST
Deputy Assistant Secretary of the Air Force
(Environment, Safety and Occupational Health)

# DECISION SUMMARY

## INTRODUCTION

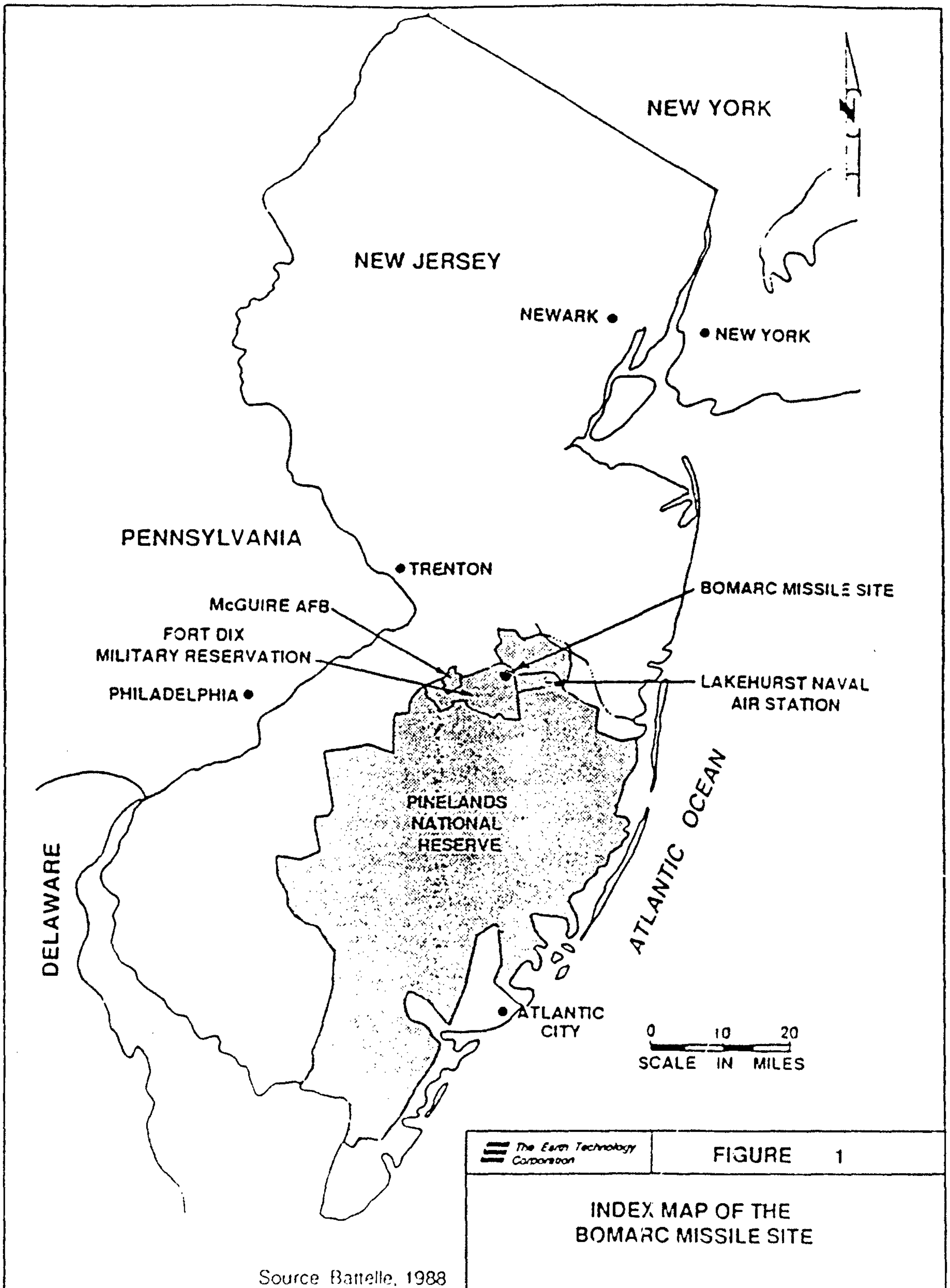
Pursuant to Executive Order 12580 (Superfund Implementation) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the Air Force performed a Remedial Investigation/Feasibility Study (RI/FS) for the Boeing Michigan Aeronautical Research Center (BOMARC) Missile Accident Site. The Remedial Investigation (RI) characterized the nature and extent of radioactive contamination in the soil, structures, groundwater, surface water, sediments, and air. The Baseline Radiological Hazard Assessment evaluated potential effects of the contamination on human health and the environment. The Feasibility Study (FS) evaluated alternatives for remediation of radioactive wastes found at the site.

## I.SITE NAME, LOCATION, AND DESCRIPTION

McGuire Air Force Base (AFB) occupies 3,536 acres in south-central New Jersey, 18 miles southeast of Trenton, New Jersey (Figure 1). It borders the community of Wrightstown (to the north) in Burlington County (Figure 2). The eastern, southern, and western boundaries of McGuire AFB border the U.S. Army Fort Dix installation. McGuire AFB also leases the BOMARC Missile Site land from Fort Dix. This site is detached from McGuire AFB and lies approximately 11 miles east of the Base (Figures 1 and 2).

### A.BOMARC Missile Site Description

The BOMARC Missile Site occupies approximately 218 acres just east of Ocean County Highway 539 in Plumsted Township, Ocean County, New Jersey. It lies about 11 road




The Earth Technology Corporation

FIGURE 1

INDEX MAP OF THE
BOMARC MISSILE SITE

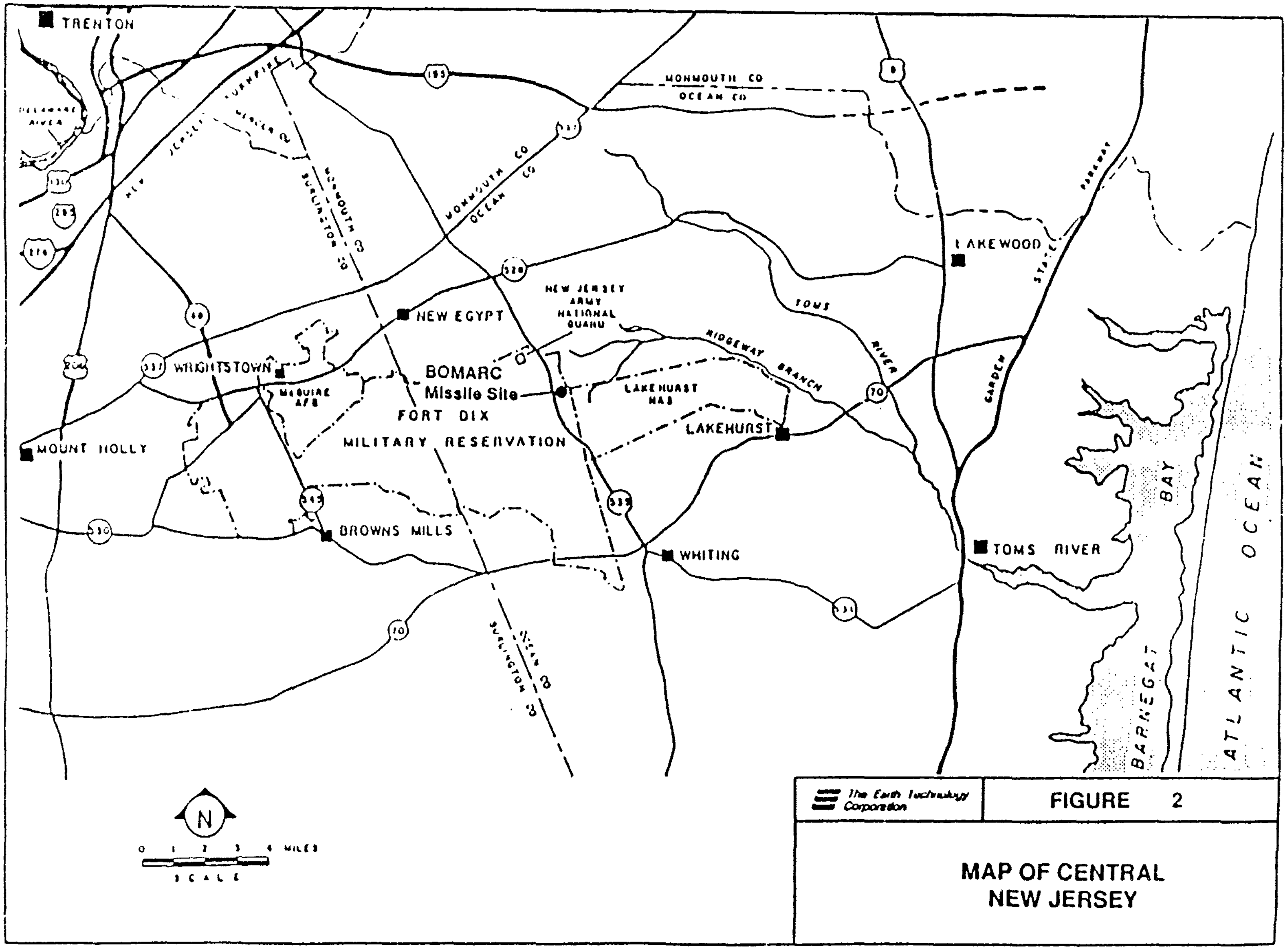



FIGURE 2

MAP OF CENTRAL NEW JERSEY

miles east of McGuire AFB and is contained within the Fort Dix Military Reservation on land leased to the Air Force (Figure 2). Rows of shelters housing launchers and BOMARC missiles were built at this facility during the late 1950s and early 1960s (Figure 3). The facility was deactivated in 1972, with all missiles removed from the launcher shelters, and the shelters themselves locked. Although the site has been deactivated, it remains under the Air Force lease and jurisdiction. Figure 3 shows the BOMARC Missile Site and surrounding area.

## B. Missile Accident History

On June 7, 1960, an explosion and fire occurred in BOMARC Missile Shelter 204. The fire burned uninhibited for about 30 minutes. The force of the explosion destroyed portions of the shelter roof, flames rose to 20 feet, and black smoke blanketed the area. At the time of the fire a north-northeast wind of 2 to 8 knots blew smoke into surrounding areas. Some of the plutonium contained in the nuclear warhead, which readily adheres to dust and smoke particles, may have been carried aloft on the northeasterly wind and dispersed.

As part of the fire-fighting activity, the area was sprayed with water from fire hoses for approximately 15 hours. As a result, plutonium-contaminated water flowed under the front door, down the asphalt apron and street, and into the drainage ditch leading outside the site boundary. An earthen dam was reportedly constructed across the ditch to contain the contaminated water. Despite extensive research efforts, the nature and location of the earthen dam has not be established. The drainage ditch runs southerly from Shelter 204, paralleling the site boundary fence for several hundred feet before entering an underground culvert and crossing underneath Ocean County Highway 539. From this point the culvert opens into a sandy ditch that eventually flattens into a wooded area (Figure 3).

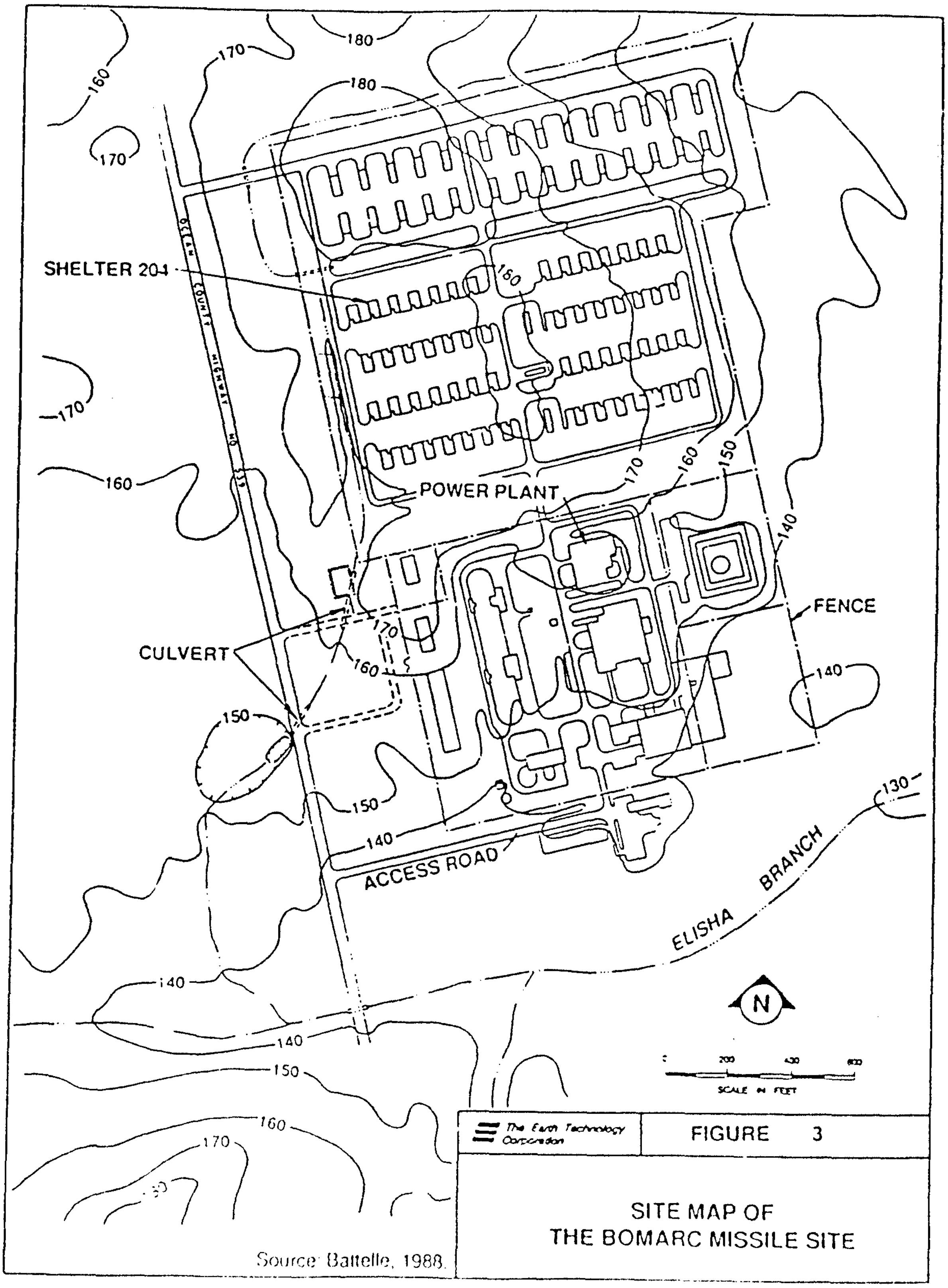



FIGURE 3

SITE MAP OF
THE BOMARC MISSILE SITE

Although no nuclear explosion took place, the nuclear warhead was burned and melted, the missile was destroyed, and the launcher shelter was badly damaged. In addition tothe severely damaged roof, the floor and concrete walls were pitted by flying fragments of the helium and fuel tanks, steel roof beams were deformed, and the shelter walls received heat damage. The residue of the burning warhead contaminated the concrete floor. The remains of the warhead and all residue from the floor were placed in plastic bags and then into sealed cans for disposal. The nuclear material was separated by grade, and the high-grade nuclear material was shipped to the Medina Base in San Antonio, Texas, and then to the U.S. Department of Energy (DOE) Pantex facility in Amarillo, Texas. The nuclear material was examined and analyzed. The exact amount of plutonium contained in the warhead is classified. According to an Air Force summary report on recovery and analysis of the nuclear materials, it is estimated that no more than 300 grams of weapons-grade plutonium was unaccounted for.

The Air Force has implemented a program of site control and monitoring in the intervening years since the missile accident occurred. Soon after the accident, a coating of fixative paint was applied and a 4- to 6-inch layer of concrete was poured over the most heavily contaminated portions of the asphalt apron and the floor of Shelter 204. These actions have effectively contained contaminants found in these areas through the present time. In addition, an asphalt cover was placed in the drainage ditch leading from Shelter 204 in order to prevent erosion of contaminated soils from the ditch. The site is fenced with a 6-foot chain-link fence topped by barbed wire, precluding access.

The Air Force has also monitored the site on an annual basis since the missile accident. Monitoring activities including radiation surveys and sampling of environmental media have shown that the distribution of radioactive contaminants found on-site has remained relatively stable since the accident.

## C. History of Site Investigation

Since 1960, many radiation surveys have been conducted on and around the BOMARC Missile Site. The Air Force Radiological Health Laboratory (now the Armstrong Laboratory), Brooks AFB, Texas has conducted surveys since 1960 and, in 1973, was directed by the Department of the Air Force to initiate an annual survey program. Surveys have also been conducted by the Army Environmental Hygiene Agency, the U.S. Army Radiation Team, Ballistics Research Laboratory, EG&G Inc., and others in recent years.

Confirmed radiological surveys occurred on or about the following dates:

- June 8, 10, 11, 16, 24-28, 1960
- November 21-24, 1966
- October 1970
- August 22-27, 1971
- October 16-20, 1972
- March 19-23, 1973
- November 13-14, 1973 (ARMS)
- May 20-29, 1975
- April 29, 1976 (Soils)
- May 17-20, 1976
- September-December, 1976 (Installation Assessment)
- June 1978
- October 1979
- 1981
- 1982
- 1983
- 1984
- September 15-21, 1985
- October/November, 1985 (groundwater and air dispersion modeling)
- October 1986
- September 1987

The Air Force Installation Restoration Program (IRP) was initiated at the BOMARC Site in October 1986, with an IRP Confirmation/Quantification Study. Soils and groundwater were sampled and analyzed for radioactive contaminants, and a report (Weston, 1987) was issued in August 1987. An IRP Remedial Investigation/Feasibility Study (RI/FS) was initiated in January 1989. Groundwater, surface water, soils, sediments, structural materials, and air were sampled and analyzed for radioactive contaminants. Risks to human health and the environment were quantified, and remedial alternatives were evaluated. The final RI/FS was issued in May 1992. Concurrent with the RI/FS, an Environmental Impact Statement (EIS) detailing environmental impacts of remedial alternatives was developed.

## II. COMMUNITY RELATIONS

### A. Community Relations During the RI/FS and EIS

During the performance of the RI/FS and EIS, the Air Force actively solicited comments and input from the community and from various regulatory agencies including the U.S. Environmental Protection Agency (EPA), New Jersey Department of Environmental Protection and Energy (NJDEPE), and the New Jersey Pinelands Commission. Public input on RI/FS activities was obtained through a series of Technical Review Committee (TRC) meetings which were held throughout the life of the project. TRC meetings were held during the planning phase in order to obtain community/regulatory input on planned activities, and during the investigation phase in order to inform the public/regulators of progress and findings. In addition to the TRC meetings, an information repository containing site information and documents pertaining to site activities was established at the McGuire Air Force Base Environmental Management Office.

### B. Community Relations to Support Selection of a Remedy

Community relations programs were conducted in support of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) RI/FS and the National Environmental Policy Act (NEPA) EIS.

To resolve any public agency concerns relative to selection of a remedy, an interagency meeting was conducted on January 9, 1992. The meeting was attended by the U.S. EPA Region II (Environmental Impacts Branch, Radiation Branch, Superfund Branch), the NJDEP (Program Coordination, Bureau of Environmental Radiation, Bureau of Groundwater Pollution Abatement, and Bureau of Federal Case Management), and various Air Force representatives. Several major issues were resolved including modifications to the methodology used to establish an acceptable cleanup level for the Off-site Disposal Alternative. Based on the discussion among the Air Force, the U.S. EPA, and NJDEPE, it was agreed that the cleanup level was to be based directly on the output from RESRAD. RESRAD is a computer code used by DOE which was developed specifically for the purpose of determining cleanup criteria. An effective dose equivalent of 4 millirem (mrem) per year was used as the input into RESRAD as the dose limit. This dose represents an acceptable lifetime cancer risk of less than $10^{-4}$.

### 1. CERCLA Process

The Draft RI/FS was issued as a companion document to the Draft EIS on September 13, 1992. The Draft RI/FS was supplied to local libraries including:

- Ocean County Public Library, Toms River, New Jersey
- Ocean County Public Library, Lakehurst, New Jersey
- Ocean County Public Library, New Egypt, New Jersey
- Burlington County Library, Mt. Holly, New Jersey.

The Draft RI/FS was also distributed to numerous representatives of NJDEPE and EPA.

In accordance with Sections 113 (k)(2)(B)(i-v) and 117 of CERCLA, the public was given the opportunity to participate in the remedy selection process. The proposed plan, which summarized the alternatives evaluated and presented the preferred alternative, was mailed to approximately 40 interested parties in May, 1992. The Air Force provided notice through a display ad in the Burlington County Times, Trenton Times, Ocean County Observer, and Asbury Park Press to explain the proposed plan, list the public comment period, and announce the public meeting. A news release was provided to the following:

- Daily Papers:
  - Asbury Park Press
  - Burlington County Times
  - Courier-Post
  - Newark Star Ledger
  - Ocean County Times-Observer
  - Trenton Times
  - Trentonian
  - Philadelphia Inquirer
- Weekly Papers:
  - New Egypt Press
- Television:
  - KYW-TV (3) NBC
  - WPVI-TV (6) ABC
  - WCAU-TV (10) CBS
  - NJN (70) Independent
  - WTAF-TV (29) FOX
- Wire Services:
  - Associated Press.

The three media representatives who attended the BOMARC Public Hearing included representatives of:

- The New Egypt Press
- The Times of Trenton
- The Asbury Park Press.

A 45-day comment period was held from May 28 to July 15. There were no requests for extensions. Approximately 40 people attended a public meeting held on June 20, 1992 at the Fort Dix Reception Center. The written comments, which were received during the public comment period, are included in the Responsiveness Summary attached to this ROD.

## 2. NEPA Process

In order to achieve a high level of public involvement in the remediation of the BOMARC Site, an EIS was prepared, in accordance with NEPA of 1969. In accordance with Air Force guidance and pursuant to the requirements of NEPA and 40 CFR 1500, a notice of intent to prepare an EIS concurrently with an RI/FS for the BOMARC Missile Site, McGuire AFB, New Jersey, was published in the *Federal Register* on December 22, 1988.

A public scoping meeting plan was also prepared. Two public scoping meetings for this combined RI/FS and EIS were conducted on January 11, 1989. The first meeting, designed for federal, state, and local officials, was held during the morning at McGuire AFB. The second meeting was targeted for the general public and was held in the evening at Jackson Township Municipal Building. At the meetings, formal presentations were provided, detailing the background on the BOMARC Missile Site and explaining the processes to be used to prepare the RI/FS and EIS documents.

Following the summary of the formal presentation, comments were solicited from the regulators and the public so that all problems and public concerns could be identified and incorporated into the scope of the EIS. Problems, concerns, and issues expressed at the scoping meeting are summarized in the EIS.

A notice regarding filing of the Draft EIS was published in the *Federal Register* on Seotember 13, 1991, concurrent with distribution of the Draft EIS. A public hearing on the Draft EIS was held on October 3, 1991. Public comments were accepted from September 13, 1991 until October 28, 1991, and were incorporated into the Final EIS, which was published in May 1992.

## III. SCOPE AND ROLE OF RESPONSE ACTION WITHIN SITE STRATEGY

The RI evaluated the nature and extent of radioactive contamination in all potentially affected media including groundwater, soil, surface water, sediment, air, and structural materials. Results from the RI and Baseline Radiological Hazard Assessment indicate that remediation is not required to address migration of contaminants off-site. However, removal of radioactive contaminant sources on-site would protect human health and the environment. At present, residual radioactivity is on-site at levels that would result in an unacceptable radiation dose to persons who may occupy the site at some time in the future. Excavation and removal of contaminated materials would enable the site to be put to alternate use. Therefore, removal of radioactive waste sources is an effective proactive remedy that is protective of human health and the environment, as outlined in this ROD.

The final selected remedy includes: (1) excavation of soils contaminated above cleanup criteria; (2) demolition and consolidation of structures contaminated above cleanup criteria; (3) transportation and Off-site Disposal of radioactive soils and structural wastes in a permitted U.S. DOE radioactive waste disposal facility. However, the Air Force recognizes the uncertainties associated with disposal of radioactive contaminated waste at a DOE facility. Until an agreement is finalized that allows for cost-effective disposal, the Air Force will retain the option to implement the NEPA No Action as an interim remedy.

The NEPA No Action would require continuation of ongoing access restrictions and other institutional controls at the site. In addition, the Air Force would restrict access to additional areas and increase site maintenance, monitoring, and inspection activities. The interim NEPA No Action remedy, while not proactive, is protective of human health and the environment.

## IV. SUMMARY OF SITE CHARACTERISTICS

### A. Environmental Setting

#### 1. Site Geography

The BOMARC Missile Site, located in Ocean County, New Jersey, is in a heavily wooded semi-rural part of east-central New Jersey. It lies inland from the coast near the northern boundary of the New Jersey Pinelands (Pine Barrens). The Site is located along the northern boundary of the outer coastal plain section of the Atlantic Coastal Plain Physiographic Province. Coastal plain topography is gently rolling with elevations ranging between 60 and 180 feet above mean sea level (msl). It is generally low-lying, with poor drainage, many swamps, and slow-flowing steams. Maximum elevation at the BOMARC Missile Site is about 180 feet above msl near Shelter 204 and decreases to about 130 feet above msl at the southeastern perimeter of the facility.

A major drainage divide separates the inner coastal plain from the outer coastal plain. The inner coastal plain drains into the Delaware River Basin, while the outer coastal plain drains directly to the Atlantic Ocean. The BOMARC Missile Site lies in the outer coastal plain, just east of the drainage divide. Streams in the outer coastal plain generally flow to the southeast. The nearest and only natural drainageway in the vicinity of the site is the northeast-trending Elisha Branch of the southeast-trending Toms River, located to the south of the site.

The area is generally semi-rural, with nearby small towns of New Egypt (6 miles), Wrightstown (10 miles), Whiting (5 miles), Lakehurst (6 miles), and Browns Mills (9 miles). There are no private residences within a 1-mile radius of the site. The nearest private residence lies just over 1 mile north-northwest of the facility fence. The primary land use within several miles of the site is military, but the sections of the two military reservations immediately adjoining the site are not often used for active military operations. A New Jersey Army National Guard post located about 1 mile west-northwest of the BOMARC facility is used for heavy land vehicle (tanks, etc.) training.

## 2. Site Geology

Geologic units ranging in age from Cretaceous to Quaternary have been identified in the Atlantic Coastal Plain Province. These units are typically unconsolidated materials consisting of gravel, sand, silt, clay, glauconite, marl, and organics, resting unconformably on a Precambrian crystalline basement complex.

The stratigraphy of the BOMARC Missile Site is dominated by interbedded continental and marine sands and clays. Surficial materials consist of a relatively thin expression (40 feet or less) of the Cohansey Sand, underlain by an unknown thickness of the Kirkwood Formation.

The Cohansey Sand [Pliocene(?) and Miocene] is a light gray to yellowish-brown, well-sorted, cross-bedded, pebbly, fine- to coarse-grained, ilmenitic, partly arkosic quartz sand, often cemented locally with iron oxide (limonite). Small seams of dark, massive, carbonaceous, kaolinitic and illitic silty clays are interbedded int he sands. Crossbedded gravels are found in channels with pebbles of quartz and quartzite. At the BOMARC Missile Site the Cohansey Sand is a fine- to coarse-grained quartzose sand with lenses of gravel that are usually one foot or less in thickness. Limonite staining produces a generally yellowish sand, but shades of red, brown, gray, and white are also found. Near the coast, the Cohansey Sand can reach thicknesses of as much as 150 feet, but the unit near the BOMARC Missile Site is probably closer to 50 feet thick. This formation forms the surface or near-surface aquifer in much of the region.

The Kirkwood Formation (Miocene) consists of light gray to yellowish-brown, moderately well-sorted, pebbly, lignitic, micaceous, fine- to very-fine-grained quartz sand. It often contains kaolinitic clay or silt, with locally thick beds of clayey silt and fine-pebble gravel. There is a basal unit of pebbly, fine quartz sand or medium gray to dark brown, lignitic quartz sand and silt. The thicknesses range from 50 to 250 feet. This formation is hydraulically connected to the Cohansey Sand, and combined, these formations form the surface or near-surface aquifer in the area.

### 3. Site Soils

Natural Soils. The Lakewood Series is the predominant natural soil series at the BOMARC Missile Site. The Lakewood soils consist of 7 to 10 inches of gray sand overlying 20 to 25 inches of dark brown to yellowish-brown sand to a depth of about 60 inches. These soils are characterized as excessively drained; they are coarse, conducive to rapid water percolation, and have low soil moisture retention and low nutrient content. Permeabilities range from 0.2 to 6.3 inches per hour.

Urban Land Unit(s). As a consequence of Base development/construction activities, the predominant category of soil on the site proper is mapped as "sandy urban land." Urban land map units are generally so variable that their properties are not characterized by the Soil Conservation Service. Use constraints are probably severe due to the great permeability in the unit(s).

### 4. Groundwater Resources

The Coastal Plain is underlain by a succession of aquifers and aquitards. The principal aquifers of the Pinelands are the shallower Cohansey/Kirkwood and the deeper Potomac/Raritan/Magothy.

Public water supplies in Ocean County are obtained entirely from ground water sources. Water use in the region is predominantly from the Potomac/Raritan/Magothy aquifer system. While the Cohansey/Kirkwood system is not currently in wide use for potable water, the system is under consideration for supplementary supplies for several large metropolitan areas. Usable standing water reserves in the Cohansey alone are estimated at $10.8 \times 10^{12}$ gallons (Rhodehamel, 1970).

Local aquifers contain water that is of generally good quality but with high iron, manganese, and TDS, as well as hardness problems, variations in pH, and disagreeable odors (often hydrogen sulfide, "rotten eggs.") In addition, overpumpage of some of the aquifers in certain areas has led to a lowering of the ground water table, occasionally accompanied by salt water intrusion.

### 5. Biology and Ecology

The BOMARC Missile Site is located within the Pinelands, and its flora and fauna are typical of the region. The vegetation of the region is primarily coniferous forest, composed largely of pitch pine that is seldom more than 50 feet in height, along with stands of blackjack oak and post oak. It is a region of sand and gravel, with few hard rock outcrops, and a low rolling topography. Soils are well drained (porous) and allow rapid percolation of water from the surface. Streams in the area are slow moving, shallow, tea-colored, acidic, and low in nutrients.

The vascular flora of the area numbers about 800 species (Pinelands Commission, 1980; Means et al., 1981), varieties, and forms and is unique with respect to the many plants that reach northern and southern range limits in this region. Fourteen (14) northern plants reach their extreme southern range limits in Pine Barrens. These comprise about 1.8 percent of the total flora. At least 109 southern plants reach their extreme northern range limits in the Pine Barrens. These comprise about 13.5 percent of the total flora.

The Pine Barrens fauna is characterized by generally having few species (about 400 animal species, Means et al., 1981; Pinelands Commission, 1980) with many individuals per species. The fauna is also of interest because few animal species are restricted to the Pine Barrens, but many southern species reach the limits of their northern range here.

The Pine Barrens' herpetofauna comprises 53 species: 10 salamanders (3 are extremely rare), 13 frogs and toads, 9 turtles, 3 lizards, and 18 snakes. The most common herpetofauna representative in upland sites (the BOMARC Missile Site is upland) are the fence lizard, box turtle, and pine snake.

Fish in Pine Barrens' waters are represented by only 24 species. This is largely due to the shallow, warm, slow moving, acid waters of the region and to the fact that all streams originate within the region, with no through-flowing streams crossing the Pine Barrens. Small sunfish, catfish, and pickerel are common.

The Pine Barrens apparently lack the diversity of habitats to support high numbers of bird species, resulting in an avifauna comprised of few species with large numbers of individuals. Upland representatives include grouse, crossbills, pine and prairie warblers, brown thrasher, and titmice.

The most conspicuous mammal is the white-tailed deer. The herbivorous deer have no natural predators in the modern-day Pine Barrens, although large numbers are harvested annually by hunters. The most common carnivores are bats and shrews. Moles, pine mice, and white-footed mice are common in upland areas. Thirty-four mammal species are present in the Pine Barrens.

The Pinelands region is broken into uplands and lowlands. The uplands are generally arid because the sandy soils allow rapid percolation of water down to the water table. Fire has played a large part in the shaping of the types of vegetation found in the upland areas because types that are either fire-resistant (blackjack and post oak) or require fire to complete their life-cycle process (pitch pine) are dominant.

The lowlands are characterized by a groundwater table that often intersects the land surface, forming bogs. These bogs are cultivated for cranberries, which comprise one of the most predominant crops in the region.

## B. Volumes and Types of Contaminated Materials

No concentrations of radionuclides attributable to the missile accident were detected in groundwater, surface water, or air at the site. The contaminants of concern, plutonium and americium, have been detected in site soils, sediments, structural materials and beneath the concrete apron. The location and activity ranges are presented in Figure 4. There are five categories of contaminated media, based on physical characteristics:

- Contaminated soils and sediments
- Contaminated apron and drainage ditch cover (concrete and asphalt)
- Shelter 204 (above-ground structures)
- Utility structures (underground)
- Missing missile launcher (potentially contaminated).

Table 1 summarizes estimated areas and volumes of contaminated media.

Contaminated Soil. Based on data from the RI, radionuclide contamination in soils is mainly in the surficial foot of the soil column and is concentrated in discrete "hot spots." This field observation correlates well with known aqueous solubilities of plutonium and americium isotopes. Radionuclides do not appear to have migrated more than a few inches vertically since the 1960 accident. The current areal extent of contamination appears to be largely the result of fallout from the accident, mechanical tracking, and fire fighting activities, which consisted of flushing Shelter 204 with approximately 30,000 gallons of water.

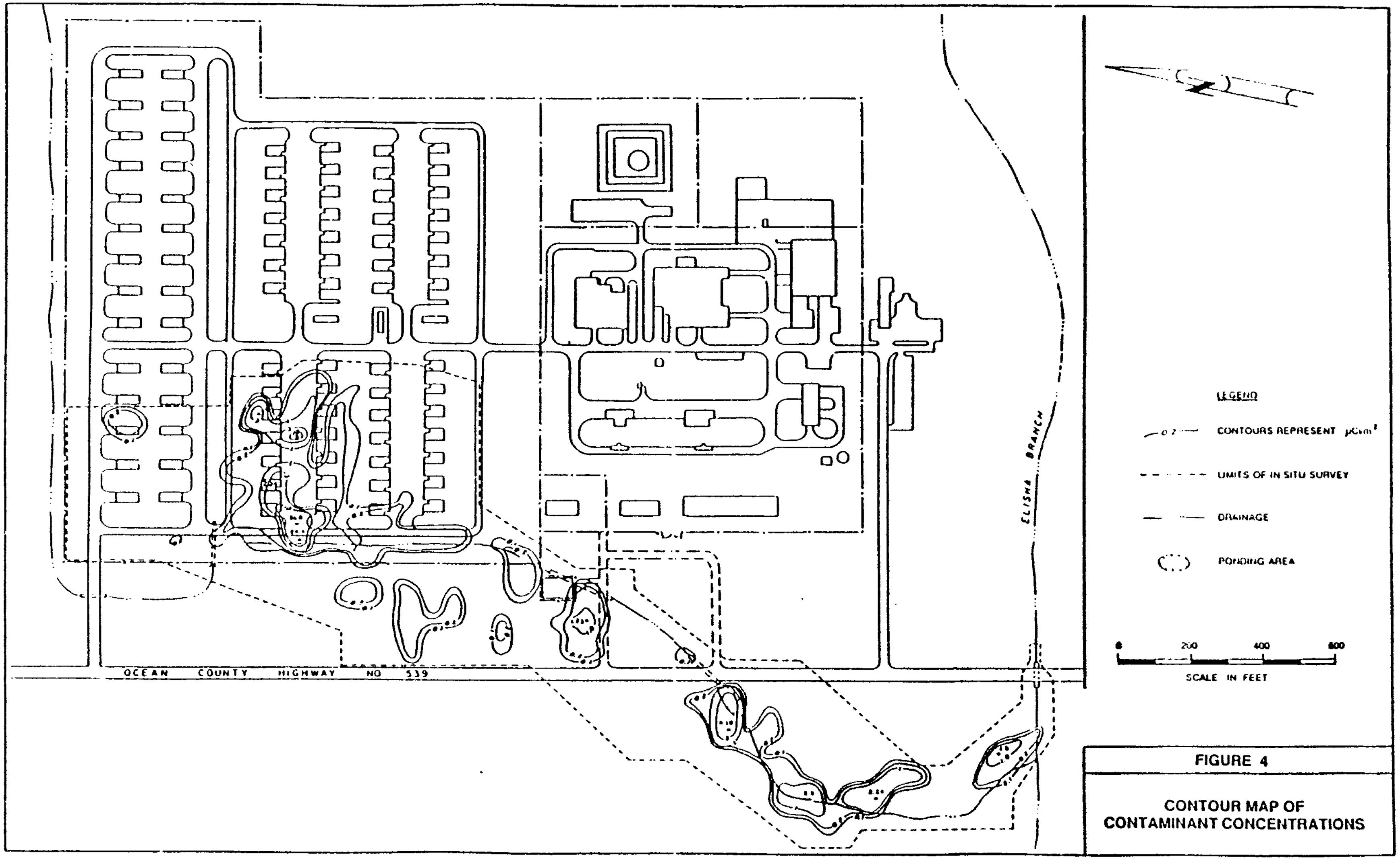



**FIGURE 4**

**CONTOUR MAP OF CONTAMINANT CONCENTRATIONS**

**Table 1**
**Estimated Areas and Volumes Affected by Response Objectives**

| Contaminated Media | Action Level | Area ($yd^2$) | In-Place Volume[a] ($yd^3$) | Expanded[b] Volume ($yd^3$) |
|---|---|---|---|---|
| Soils and Sediment | 8 pCi/g | 11,650 | 5,150 | 6,200 |
| Concrete Apron | c | 2,500 | 291 | 582 |
| Asphalt Apron | N/A | 3,200 | 178 | 356 |
| Asphalt Cover in Drainage Ditch | N/A | 1,120 | 62 | 124 |
| Shelter 204 | c | 584 | 201 | 402 |
| Utility Bunkers | c | 38 | 18.5 | 37 |
| Missile Launcher | c | 14 | 5 | N/A |

a In-place volumes. Does not include volume increase from excavation.
b Excavated volumes. Includes expansion factor of 0.20 for soils, 2.0 for asphalt and concrete.
c NRC Guide 1.86 criteria: <20 dpm/100 $cm^2$ removable activity, <300 dpm/100 $cm^2$ maximum activity; <100 dpm/100 $cm^2$ average activity.

The depth of plutonium contamination greater than the risk-based cleanup level of 8 picoCuries/gram (pCi/g) was generally less than 1 foot across the site, with a few exceptions, which are discussed below.

Soil borehole sampling data presented in the RI indicate that plutonium activity for samples taken below a depth of 2 feet was less than 8 pCi/g in all but two boreholes. At a location just west of Shelter 204, the sample from the 2- to 4-foot interval had 8.1 pCi/g, and the sample from the 8- to 10-foot interval had 39 pCi/g plutonium.

This location probably received a heavy discharge of firefighting water, which may be the reason for the increased depth of contamination. Since the full depth of contamination above the 8 pCi/g cleanup level at this location was not defined, any active restoration remedial alternative selected will require pre-design sampling at this location to establish the target depth for remediation. At a location just outside the southwestern site perimeter, where the contaminated drainage channel passes beneath the fence, a sample from the 2- to 4-foot interval had 10 pCi/g plutonium, and a sample from the 4- to 6-foot interval had no plutonium detected.

Soil sampling data presented in the RI also indicate that plutonium contamination in excess of 8 pCi/g extends to a depth of at least 18 inches in a small area of the asphalt-covered drainage ditch just off the concrete apron. Samples below 18 inches were not obtained at this location, so the vertical extent of contamination is undetermined. Since the full depth of contamination above the 8 pCi/g cleanup level at this location was not defined, any active restoration remedial alternative selected will require pre-design sampling at this location to establish the target depth of remediation.

Due to the non-uniform soil deposition of plutonium in discreet particles, it is difficult to contour concentrations of plutonium in site soils with a high degree of accuracy. This makes estimation of volumes of soil requiring remediation problematic. In order to obtain a conservative estimate for volumes of soil to be remediated, several factors were taken into consideration.

One factor considered was the potential effect of demolition of contaminated structures (concrete apron, asphalt cover in drainage ditch, Shelter 204) on surrounding soils.

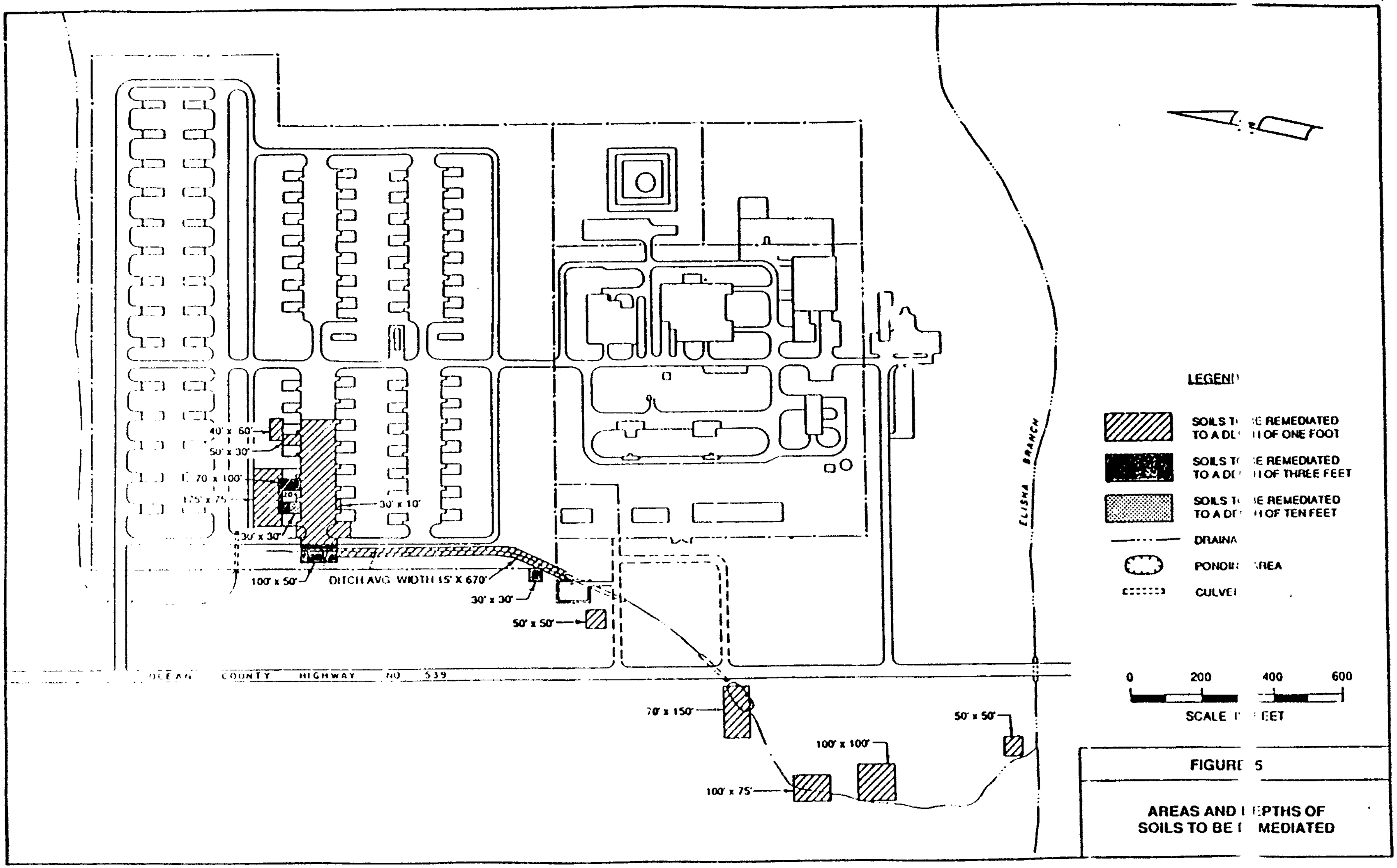



FIGURE 5

AREAS AND DEPTHS OF SOILS TO BE REMEDIATED

Engineering controls designed to minimize the release of contaminants will be implemented during any demolition activities, however, it is likely that small amounts of soil beneath and adjacent to the shelter and concrete apron become contaminated. Any soils affected require remediation after demolition is complete. In order to estimate the volume of soils affected, "buffer zones" of soils potentially requiring remediation were established beneath and adjacent to the structures. Figure 5 shows areas and depths of soils to be remediated.

In establishing the "buffer zones" of soils to be remediated, the following assumptions were used:

- 100 percent of the concrete/asphalt apron be removed. In addition, the contaminated asphalt located just east of the apron (approximately 90 × 70 feet, see Figure 5) and small areas located just north and south of the pad at the west end of the pad will be removed. One foot of soil from beneath the concrete and asphalt require remediation; this equates to a surface area of approximately 3,480 square yards and a volume of approximately 1,400 cubic yards using an expansion factor of 0.20.

- An area extending beneath Shelter 204 and 10 to 30 feet from all sides of the shelter be affected; soils within most of this area require remediation to a depth of three feet. Soils in a small (30 feet × 30 feet) area just west of Shelter 204 require remediation to a depth of 10 feet. This equates to a surface area of approximately 775 square yards and a soil volume of approximately 1,215 cubic yards using an expansion factor of 0.20.

In addition to soils from the "buffer zones" described above, several discontinuous areas of contaminated soil require remediation. These include soils from the following areas:

- Two areas just north and west of Shelter 212 measuring approximately 40 feet by 60 feet and 50 feet by 30 feet, respectively (Figure 5). Total surface area is approximately 430 square yards. Assuming a depth of excavation of 1 foot and an expansion factor of 0.20, the total excavated volume is estimated at 175 cubic yards.

- The asphalt-lined drainage ditch area. Although results from the HPG survey indicate that most of the ditch is well below the risk-based cleanup level, laboratory analyses of soils presented in the RI indicate that soils beneath the asphalt are contaminated at levels exceeding the risk-based cleanup level of 8 pCi/g over most of the length of the ditch. These data points represent widely spaced "hotspots," so it is likely that a large portion of soils in the ditch are uncontaminated. However, in order to obtain conservative estimates for volumes of soil to be remediated, it is assumed that all soils beneath the asphalt are contaminated to a depth of 1 foot except in the area just west of the concrete apron shown in Figure 5, where the depth of contamination is assumed to be 3 feet. That area is discussed separately below. Total area of the asphalt-covered portion of the ditch is approximately 1,120 square yards. Assuming a depth of excavation of 1 foot and an expansion factor of 0.20 the total volume of soils is estimated at approximately 450 cubic yards.

- The area just west of the concrete apron, measuring approximately 50 feet by 100 feet. Total surface area is approximately 555 square yards. Assuming an excavation depth of 3 feet and an expansion factor of 0.20, the total excavation volume is estimated at 670 cubic yards.

- An area north of Shelters 202, 204, and 206, measuring approximately 175 feet by 75 feet. Total area is approximately 1,460 square yards. Assuming a depth of excavation of 1 foot and an expansion factor of 0.20, the total excavation volume is estimated at 585 cubic yards.

- An area just south of the concrete apron measuring approximately 30 feet by 10 feet. Total area is approximately 33 square yards. Assuming a depth of excavation of 1 foot and an expansion factor of 0.20, the total excavated volume is estimated at 13 cubic yards.

- An area just west of the drainage ditch where the ditch exits the site perimeter fence measuring approximately 30 feet by 30 feet. This area corresponds to the location of borehole 20. Assuming a depth of excavation of 3 feet and an expansion factor of 0.20, the total excavated volume is estimated at 120 cubic yards.

- An area located east of Highway 539, between the site perimeter fence and the highway measuring approximately 50 feet by 50 feet. Assuming a depth of excavation of 1 foot and an expansion factor of 0.20, the total excavated volume is estimated at 110 cubic yards.

- Four areas east of Highway 539 measuring approximately 70 feet by 150 feet, 100 feet by 75 feet, 100 feet by 100 feet, and 50 feet by 50 feet, respectively. Total surface area (for all four areas) is approximately 3,390 square yards. Assuming a depth of excavation of 1 foot and an expansion factor of 0.20, the total excavated volume is estimated at 1,355 cubic yards.

- Soils associated with the missing missile launcher may be contaminated, although the degree of contamination and volume affected are unknown. It is conservatively estimated that 100 cubic yards of soil associated with the launcher require remediation.

The sum of estimated soil volumes to be remediated is approximately 6,200 cubic yards.

Contaminated Apron. Based on field measurements conducted during the RI, total contaminated area of the apron area in front of Shelter 204 is approximately 28,800 square feet. Concrete core samples had levels of plutonium as high as 1,070 $\mu$Ci/sample on the contact between concrete and underlying asphalt. Although sampling data from the RI indicates that portions of the apron are uncontaminated, the entire apron will be remediated. This is due to the uncertainties associated with gamma radiation detection through concrete. This 28,800 square foot area includes 6,300 square feet of asphalt that is not covered by concrete, located just east of the concrete-covered portion of the apron. Based on available information, the thickness of the apron is 4 to 6 inches of concrete underlain by 2 inches of asphalt, yielding a total unexpanded concrete volume of about 291 cubic yards and a total unexpanded asphalt volume of about 178 cubic yards. At the base of the apron is 2 inches of asphalt upon which strippable paints of unknown composition were initially applied. On top of the paint layer, 4 inches of concrete were later placed. A small area (2,592 square feet) directly in front of Shelter 204 has an additional 2-inch layer of concrete. The surface of the concrete is cracked in several places with tar/asphalt patch material found in the crevices. Sampling of soils beneath the apron indicates low levels of radionuclide contamination that are probably due at least in part to contamination introduced during the concrete coring process. See Figure 5 for the area to be remediated. The asphalt cover in the drainage ditch will require removal prior to remediation of underlying soils. It is assumed that the entire volume of asphalt is contaminated, and will require remediation. The asphalt-covered portion of the ditch is approximately 670 feet long, with an average width of 15 feet and thickness of 2 inches. This equates to an area of approximately 1,120 square yards, and an unexpanded volume of 62 cubic yards.

Shelter 204. The shelter is one of a series of above-ground buildings separated from each other by approximately 30 feet. The building consists of steel-reinforced concrete floors and walls, with steel doors and a roof composed of sheet metal and steel I-beams. The 6-inch thick concrete pad covering the apron in front of the shelter is contiguous inside the front portion of the shelter, and extends from the front (southern end) of the shelter approximately halfway (30 feet) to the rear of the shelter. The concrete was poured directly on the existing concrete floor. The dimensions of the shelter are 60 feet × 21 feet × 10 feet high. The location of the front doors and sheet metal portion of the roof are unknown. Efforts to locate these items are addressed in the discussion of the missing missile launcher. The inside of the shelter consists of two rooms separated lengthwise; a main enclosure used to house the missile, and a smaller control room. The outer walls of the control room are made of concrete blocks. The floors of both rooms have a 3.5-foot deep concrete pit. The estimated surface area exposed to radionuclides from the missile accident is about 6,066 square feet of concrete and concrete block and 340 square feet of steel doors (excluding I-beams on roof). Only a small portion of this concrete, mainly the floor, is contaminated. It is estimated that 100 percent of the shelter floor and 25 percent of the shelter walls (and I-beams) require remediation. The total unexpanded volume of material from Shelter 204 is estimated to be 201 cubic yards, or an expanded volume of 402 cubic yards.

Alpha surveys conducted on Shelter 204 walls and floor using a PAC-4G instrument showed that the highest activity levels detected in Shelter 204 were 2,011 $dpm/100cm^2$, 47,780 $dpm/100cm^2$, and 2,106 $dpm/100cm^2$.

Concrete cores taken through the shelter floor showed levels of plutonium as high as 65 $\mu$Ci/sample on the original floor.

<u>Utility Bunkers</u>. Underground utility bunkers supporting the missile shelter consist of two steel reinforced concrete compartments each having dimensions of 6 feet × 4 feet × 6 feet deep. The total interior surface area of each bunker is approximately 331 square feet. Bunkers were connected to each other and to the shelter by small diameter conduit carrying communications and electrical wiring, compressed gasses, and fluids. Each bunker at the time of the missile accident was accessible by a manhole with steel cover. Presumably, fire-fighting efforts washed small amounts of radioactive debris through the manholes and into the bunkers. Alpha surveys taken in the bunkers during the RI showed activity ranging up to 80,000 counts per minute (cpm). Sediments were encountered and sampled in one bunker; analytical results showed activity of 200 pCi/g. It is assumed that 50 percent of the interior surfaces of the bunkers require remediation.

The total in-place volume of materials from the utility bunkers is estimated to be 18.5 cubic yards, or an expanded volume of 37 cubic yards.

Missing Missile Launcher. The missile launcher from Shelter 204 was removed from the shelter shortly after the accident. No records exist indicating the manner of disposal of the missile launcher, although standard procedure would have been to dispose of the launcher along with other radioactive wastes, such as the missile debris. However, due to the possibility that the launcher could have been disposed of on-site, a geophysical investigation was conducted, focusing on areas thought to be potential disposal sites. Two geophysical techniques, magnetic profiling, and ground-penetrating radar profiling, were used in an attempt to identify possible burial locations on-site and near the site. As a result of the surveys, a total of five anomalous areas which could represent the buried launcher were identified. These anomalies may also represent the missing Shelter 204 doors and sheet metal portion of the roof.

The only practical means of determining if any of the observed anomalies represents the missing launcher involves excavation and inspection of the anomalies. Since excavation of the anomalies was beyond the scope of the RI/FS, excavation, inspection, and removal/disposal (if applicable) of the anomalies is being addressed as part of potential remedial measures to be used at the site. If the missile launcher is recovered and it is contaminated, it will be disposed of along with other radioactive wastes.

Approximate launcher dimensions were measured at an open shelter on-site. The launcher consisted of two main components; a base plate (8 × 8 feet, 0.25 inches thick) and missile support (30 feet × 2 feet × 2.5 feet). The combined weight is estimated at 2 to 3 tons. Due to the potential for significant deformation of the launcher caused by the intense heat of the fire, the launcher may not be in the original form. The estimated volume of material from the missing missile launcher is 5 cubic yards.

## V. SUMMARY OF SITE RISKS

As part of the RI, a baseline risk assessment (baseline radiological hazard assessment) was conducted. The objective of the baseline radiological hazard assessment was to estimate the risk due to radiological contamination at the BOMARC Missile Site in the absence of site remediation or control. The scope of this assessment includes the following: 1) a description of existing contamination, 2) methodology for assessing potential radiological impacts, and 3) results of radiological impact calculations for baseline conditions.

## A. Waste Characterization

The transuranic elements plutonium (primarily Pu-239) and americium (as Am-241) are the principal radionuclides of concern at the BOMARC site. They belong to a group of elements known as actinides that include the elements from atomic number 90 (thorium) through 103 (lawrencium), all of which are radioactive. In general, the chemistry of the actinides is extremely complex. However, the behavior of plutonium, and particularly the oxides of plutonium in the environment, has been sufficiently well studied to permit reliable assessment calculations (Hanson, 1980).

The weapons grade plutonium (WGP) found at the BOMARC site consists of approximately 93 percent Pu-239 and 7 percent Pu-240, with smaller quantities of Pu-238 and Pu-241. Both Pu-239 and Pu-240 have very long half lives and have not decayed significantly since the accident. Pu-241, however, has a half life of 13.2 years so that approximately 81 percent of the amount involved in the accident has decayed away by April 1992. As each nucleus of Pu-241 decays, one nucleus of Am-241 with a half life of 458 years is produced. As a consequence, Am-241 is also of concern at the BOMARC site. For example, after a period of 32 years (e.g., 1960 -1992), 1 Ci of Pu-241 would have decayed to 0.21 Ci, and would have produced $2.5 \times 10^{-2}$ Ci of Am-241. Over a longer period of time, for example 200 years, an initial amount of 1 Ci of Pu-241 would decay to approximately $6.6 \times 10^{-6}$ Ci, and would also result in $2.5 \times 10^{-2}$ Ci of Am-241 at the end of the time period. The same amount of Am-241 is present at the end of both

32 and 200 years; this is because over this time period, Am-241 is being produced via the decay of Pu-241 at essentially the same rate that it is decaying away.

Smaller amounts of other daughter products in this decay chain would also exist at the end of these time periods (e.g., Np-237). Over a period of 24,400 years, an initial amount of 1 Ci of Pu-239 would decay to 0.5 Ci, and would result in $8.6 \times 10^{-6}$ Ci of U-235 at the end of the time period.

## B. Source and Release Characterization

Contaminated areas and materials at the BOMARC missile accident site include the structural components of the shelter, power and communication bunkers, soil in the shelter area, asphalt, concrete, and sediments in the drainage ditch that crosses Ocean County Highway 539.

Given the nature of the accident, the amount of residual radiological contamination at the BOMARC accident site is difficult to determine accurately. The best available data, summarized in the RI, indicates that no more than 300 grams of plutonium was unaccounted for following the accident.

The primary isotope in WGP is Pu-239, but small quantities of Pu-238, Pu-240, Pu-241, and Am-241 (from beta decay of Pu-241) are expected to be present. These contaminants are found in or on soil, concrete, asphalt, and steel. The radioactive contamination is not distributed uniformly over the site, but occurs in discrete "hot spots," which in several instances have been found to be a single particle.

The site characterization data supporting the RI/FS were used to determine characteristics such as average concentrations of Pu-239 in soil, depth of contamination, and other physical characteristics. For the purposes of the baseline radiological hazard assessment, the total area of contamination at the BOMARC site is estimated to be

76,500 $m^2$, with an average Pu-239 contamination level of 32 pCi/g. The ratio of Pu-239 activity to Am-241 activity is 5.9 to 1.

## C. Transport and Fate of Contamination

The oxides of plutonium and americium are relatively insoluble in water and have a high affinity for soil particles. As a consequence, these elements are not highly mobile in the environment and are not readily taken up by plants and animals. This is illustrated by the values of the four quantities that are typically used for assessment purposes to define the movement of radionuclides through food chains (see Table 2).

**Table 2**
**Dose Contributions for Individual Radionuclides and Routes: Maximally Exposed Individual**

| | Percent of Total Dose by Route | | | | | | |
|---|---|---|---|---|---|---|---|
| **Radionuclide** | **Ground** | **Dust** | **Plant** | **Meat** | **Milk** | **Soil** | **Total** |
| Am-241 | 0.2 | 11.1 | 0.2 | 0.1 | 0.0 | 3.4 | 15.0 |
| Pu-239 | 0.01 | 64.8 | 0.8 | 0.4 | 0.0 | 19.0 | 85.0 |
| **Total** | 0.2 | 75.9 | 1.0 | 0.5 | 0.0 | 22.4 | 100.0 |

The distribution coefficient, $K_d$, is the ratio between radioactivity adsorbed to soil (in pCi/g) and that in solution in surrounding water (in pCi/ml). Values of the distribution coefficient vary widely depending on site-specific properties of both soil and water. Americium is generally more mobile than plutonium and has a range of $K_d$ in freshwater of about $10^2$ to $4 \times 10^4$ ml/g. Plutonium has a range under similar conditions of about $10^2$ to $10^7$ ml/g. The values given in Table 2 are the median values reported. These values indicate that the actinides adsorb strongly to soils and would not be expected to move readily in solution. Any significant dispersion of actinides in the environment would most likely be due to movement of soil particles themselves, either as wind-blown dusts or as waterborne sediments.

The $B_v$ is a plant uptake factor and is expressed as the ratio between concentration in the above-ground portions of plants growing in the soil (in pCi/g) and concentration in soil (in pCi/g). As indicated in Table 2, plant concentrations of both elements are generally about 500 times smaller than concentrations in soil. The transfer coefficient, $F_f$, is the ratio between concentration in beef (in pCi/kg) and daily intake by beef cattle (in pCi/D). The transfer coefficient, $F_m$, is the ratio between concentration in cow's milk (in pCi/L) and daily intake by dairy cows (in pCi/D). Low uptake by animals results in very low concentrations in animal products for human consumption.

## D. Exposure Pathways

Pathways at the BOMARC site include air, groundwater, surface water during heavy runoff, and physical (mechanical) transport. Any plutonium at the site that is not fixed or immobilized (i.e., by concrete or asphalt) is subject to resuspension and transport. Plutonium tends to adhere to soil particles and open-channel modeling indicates that surface water transport of plutonium-contaminated sediments could occur during heavy storm runoff. Any intrusion into contaminated soil or other materials by people or animals could cause contamination to adhere to that person or animal (or to adhere to anything removed by them) and lead to physical transport of plutonium off the site.

In general, the calculation of radiation doses to an individual is based on the exposure routes by which each radionuclide causes irradiation. There were four routes considered in the RI:

1. External exposure from submersion in a radioactive cloud.
2. External exposure from radioactivity on the ground.
3. Internal dose from inhalation of radioactivity.
4. Internal dose from ingestion of contaminated foods, soil and water.

In order to present a significant hazard from external exposure, a radionuclide must emit penetrating radiation in the form of a gamma ray, x-ray, or energetic beta particle. Among the radionuclides of concern at the BOMARC site, only Am-241 has an x/gamma-ray emission sufficient to pose a potential external exposure hazard.

Internal dose from ingestion of contaminated foods depends on the uptake of each radionuclide into foods and subsequent uptake by the human body. All actinides are poorly taken up by plants, animals, and people. Consequently, while some potential exists for radiation dose from ingestion, this would not be the dominant exposure route for plutonium and americium. Intake of contaminated groundwater is another potential source of radiological dose from plutonium. However, plutonium and americium are relatively insoluble in groundwater, and are not readily transported via groundwater movement. Finally, direct ingestion of soil occurs more frequently with infants and children than adults, but it can be an important dose contributor.

The route of primary concern for plutonium and americium is inhalation of contaminated particles. This is a consequence of three factors. First, these radionuclides are alpha particle emitters. Alpha particles have very short ranges in tissue but are very efficient at depositing their energy in a small volume. Second, the chemically inert actinide oxides remain in the lung for long periods of time. Finally, radioactive contamination at the BOMARC site exists in a form which may produce respirable particles if disturbed.

Airborne particles contaminated with plutonium and americium are the dominant exposure hazard associated with the BOMARC site. Resuspension of contaminants during undisturbed periods and generation of fugitive dust by disturbance of wastes are the primary mechanisms by which airborne transport may take place.

## E. Identification of Receptors

Two types of analyses were conducted for the baseline radiological hazard assessment. The first consists of an analysis of the potential dose to hypothetical maximally exposed individuals residing on the BOMARC site itself. The second estimates the potential collective dose to the population within 50 miles of the site.

Hypothetical Maximally Exposed Individual. This assessment evaluated the potential for radiation dose to members of the general public who may inadvertently expose themselves to current levels of contamination at the BOMARC Missile Site. Upper bound estimates of potential doses for a hypothetical maximally exposed individual have been determined using a farm family scenario. This scenario has been used in risk assessments of other radiologically contaminated sites, such as uranium mill tailing sites.

This calculation is fully implemented in a computer code called RESRAD. This code has been developed for the specific purpose of determining cleanup criteria for radioactively contaminated soils (Gilbert et al., 1989). It contains all the potential routes of exposure discussed above except external exposure from submersion in a radioactive cloud; this pathway would not be significant at the BOMARC Missile Site.

It is the position of the Air Force that institutional control of the site can be maintained indefinitely. However, in order to obtain a worst-case estimate of potential risks, a more conservative approach was taken. To estimate the upper bound of doses from intrusion, it was assumed that institutional control of the site would be discontinued at some time in the indefinite future and members of the public would have unrestricted access. It was assumed that an individual continuously resides on the existing BOMARC site and consumes foods grown in areas with the maximum contaminant concentration. In order to provide an upper bound for potential doses, it has been assumed that all the radioactivity on the site is available for transport through the environment. That is, the barriers presented by existing concrete and asphalt covers have been neglected. This scenario is considered unlikely.

Permanent residents, rather than individuals exposed by activities not associated with residential living, have been chosen as the critical population group because the exposure of permanent residents is more likely to be long-term and would generally involve exposure by more routes. Nonresident groups, such as construction workers and individuals involved in recreational activities, would receive a much smaller dose than a permanent resident because they spend less time on site.

Exposure scenarios used for establishing risk and soil cleanup guidelines should be bounding in the sense that they correspond to actions, events, and processes that would result in the largest exposure likely to occur to individuals and groups. However, they must also be credible, which implies that the probability of occurrence should be above some threshold value. The basis for specifying a credible bounding scenario is ill-defined because a threshold probability for distinguishing between a credible and a noncredible scenario has not been established, and it is usually not possible to assign a meaningful probability of occurrence for a scenario (unless the scenario is physically impossible, in which case a zero probability can be assigned). A family-farm scenario, in which a family constructs a home on the contaminated site and raises an appreciable fraction of its food on this site, is considered to be a credible bounding scenario for the purpose of this assessment. Even though such a scenario is very unlikely to occur at the BOMARC site, it cannot be excluded as noncredible at some time in the future.

Potential routes of exposure included in this analysis are external radiation from contaminated ground as well as internal radiation from inhalation, ingestion of food, drinking water, and soil. Both the effective dose equivalent (EDE) and organ dose commitments were reported in the RI. Because of the known behavior of actinides in the environment, inhalation dose is the dominant route and the lung is the critical organ.

**Potential Off-site Population Dose**. Atmospheric dispersion of contaminated material off of the BOMARC site has been evaluated using the appropriate modules of the GENII computer code. GENII is a code developed by Battelle Pacific Northwest Laboratory (PNL) to assess the radiological consequences of releases to the environment (Napier et al., 1988). It allows several options for atmospheric dispersion calculations. Further, it is coupled directly to the dosimetry calculations necessary for assessing the potential impacts to members of the public.

Potential routes of exposure calculated by GENII include external radiation from contaminated air and ground surface as well as internal radiation dose from inhalation and ingestion of contaminated foods. Both EDE and organ dose commitments are reported in the following section along with estimates of potential health effects.

## F. Carcinogenic Risks

Because expected releases of radioactive material from the BOMARC site would be small and the projected radiation dose to any individual is small, the only effects considered are long-delayed somatic effects. Acute radiation effects require exposures many orders of magnitude greater than those projected for the BOMARC site. The delayed effects considered in this assessment are potential excess fatal cancers of the lung, bone, and liver.

Hypothetical Maximally Exposed Individual. As shown in Table 2, radiation doses to a hypothetical, maximally exposed individual are dominated by inhalation of plutonium-contaminated, resuspended dust. This route of exposure accounts for approximately 65% of the total dose. Inhalation of Am-241-contaminated dust contributes about 11% of the dose.

Ingestion of plutonium and americium account for an additional 24% of the dose. Taken together, these routes of exposure resulting from internally deposited transuranic alpha-emitters account for more than 99% of the total dose. External gamma radiation dose, primarily from Am-241, accounts for less than 1% of the total. Waterborne radioactivity does not make a significant contribution to ingestion values, even for calculations taken out to periods of greater than 100 years.

Table 3 summarizes the potential radiation doses to the maximally exposed individual from each year of residence. This table also presents the total rate of excess (i.e., more than normal incidence) fatal cancers and excess fatal cancers of the lung, liver, and bone for a hypothetical population of individuals exposed to these levels of radiation. Cancer risk estimates are intended to be applied to populations rather than to individuals, so only an estimate can be provided for the maximally exposed individual.

Table 3
**Dose Rates and Health Risks:**
**Maximally Exposed Individual**

| Dose Rates (mrem/year) | | | | |
|---|---|---|---|---|
| **Radionuclide** | **EDE** | **Bone Surface** | **Liver** | **Lung** |
| Am-241 | 7 | 126 | 27 | 12 |
| Pu-239 | 40 | 734 | 156 | 72 |
| **Total** | 47 | 860 | 183 | 84 |

| Excess Fatal Cancers (cancers/year per million persons) | | | |
|---|---|---|---|
| **Total** | **Bone** | **Liver** | **Lung** |
| 19 | 13 | 3 | 3 |

| Average Excess Fatal Cancers Per Lifetime (cancers/lifetime) | | | |
|---|---|---|---|
| **Total** | **Bone** | **Liver** | **Lung** |
| $1.3 \times 10^{-3}$ | $9.0 \times 10^{-4}$ | $1.9 \times 10^{-4}$ | $2.1 \times 10^{-4}$ |

The natural incidence rate for all fatal cancers exceeds 2,500 cancers/year per million persons (NAS, 1990). In the United States, the natural incidence rate for liver cancers is about 50 cancers/year per million persons. The corresponding rate for lung cancers is about 600 cancers/year per million persons, and the rate for bone cancers is about 10 cancers/year per million.

It is useful to compare calculated dose rates to those of natural background radiation in the United States (NCRP, 1987). The estimated total dose rate of 47 mrem/year is small compared to the average annual background radiation dose of about 350 mrem/year. Similarly, the lung dose rate of 84 mrem/year calculated for this assessment is less than half of the estimated 200 mrem/year average lung dose rate resulting from exposure to naturally occurring radon. Excess fatal cancers represented by excess fatal cancers per year per million persons have been converted to excess fatal cancers per lifetime. The conversion was completed by assuming an average 70-year lifetime. The values for excess fatal cancers per lifetime presented in Table 3 estimate a health risk for the maximally exposed individual. The total excess fatal cancers per lifetime of $1.3 \times 10^{-}$

$^3$, or 1.3 excess fatal cancers per one thousand persons averaged over a 70-year lifetime, exceed the cancer risk of $10^{-4}$ or 100 excess cancers per one million persons averaged over a 70-year lifetime. A lifetime excess cancer risk of less than $10^{-4}$ is generally considered an acceptable excess cancer risk according to current U.S. EPA guidance.

<u>Off-site Population</u>. The potential baseline dose rates to the population within 50 miles of the BOMARC site are summarized in Table 4. The total dose rate of 2.8 person-rem/year is distributed over a population of about 9 million persons within 50 miles of the site. This gives an average of about $3.0 \times 10^{-4}$ mrem/year to each individual in the population, a value that is several orders of magnitude smaller than that estimated for the hypothetical maximally exposed individual. The estimated total excess fatal cancer rate is very much less than one per year ($9.1 \times 10^{-4}$ cancers/year) over nine million persons. This value can be compared to a natural incidence that exceeds 2,500 cancers/year per million persons. This natural incidence rate corresponds to a lifetime incidence of approximately 20,000 cancer deaths per 100,000 individuals (NAS, 1990).

**Table 4**
**Dose Rates and Health Risks:**
**Population Within 50 Miles***

| Dose Rates (person-rem/year) | | | |
|---|---|---|---|
| **EDE** | **Bone Surface** | **Liver** | **Lung** |
| 2.8 | 52 | 9 | 0.4 |

| Excess Fatal Cancers (cancers/year) | | | |
|---|---|---|---|
| **Total** | **Bone** | **Liver** | **Lung** |
| $9.3 \times 10^{-4}$ | $7.8 \times 10^{-4}$ | $1.4 \times 10^{-4}$ | $1.3 \times 10^{-5}$ |

***Estimated to be $9.3 \times 10^{6}$ people in 1995.**

| Average Excess Fatal Cancers Per Lifetime (cancers/lifetime) | | | |
|---|---|---|---|
| **Total** | **Bone** | **Liver** | **Lung** |
| $7.0 \times 10^{-9}$ | $5.8 \times 10^{-9}$ | $1.0 \times 10^{-9}$ | $1.0 \times 10^{-10}$ |

As discussed above for the maximally exposed individual, values of excess fatal cancers per million persons have been converted to values of excess fatal cancers per lifetime. Total excess cancers per lifetime ($6.9 \times 10^{-9}$), as well as average excess cancers per lifetime of the bone, liver, and lung, do not exceed the generally acceptable U.S. EPA criterion of $10^{-4}$ to $10^{-6}$ excess cancers per lifetime. This indicates that the health of the general off-site population is not at risk.

### G. Threat to Wildlife

The facility is fenced, with no permanent populations of deer or other large vertebrates. Rodents and other small vertebrates do inhabit the area. Vultures and other birds also reside on or near the site. At the levels of plutonium available to this resident wildlife, no threat is believed to exist.

No critical habitats are present on-site, and no endangered species are known to be affected by the site.

## VI. DESCRIPTION OF ALTERNATIVES

### A. Surface Water and Groundwater

Based on the baseline risk assessment, the levels of contamination in surface water and groundwater did not result in unacceptable exposure to radionuclides. Therefore, it was determined that no remedial action is necessary for surface water or groundwater to ensure protection of human health and the environment. However, levels of contamination in soils, sediments, concrete, asphalt, and structural materials do exceed acceptable levels and require remediation. Five remedial alternatives were evaluated in detail in the feasibility study for remediation of these materials. A description of these alternatives and the applicable or relevant and appropriate requirements (ARARs) that apply are contained in the following sections.

## B. Soil, Sediment, Concrete, Asphalt, and Structures

### 1. Alternative 1 - Unrestricted Access.

The unrestricted access alternative in this case consists of dropping institutional and access controls currently in place and leaving contaminated materials in place. The unrestricted access alternative serves as a risk scenario for quantifying risks posed by the site in the absence of remediation or control, including control measures currently in place. This alternative is functionally equivalent to the "No Action Alternative" required by the NCP.

The unrestricted access alternative potentially allows for erosion of contaminated soil, weathering of contaminated structural materials, and off-site migration of plutonium and americium through mass-wasting and sediment transport by water and air. Lack of institutional controls allows for disturbance of the site by development activities, potentially exposing on-site workers and the general public to plutonium and americium through inhalation, ingestion, and external radiation and exacerbating erosion and sedimentation problems. Public access to the site allows for exposure of the general public through inhalation and ingestion pathways.

The unrestricted access alternative would not reduce risks to human health or the environment and would not reduce the mobility, toxicity, or volume of the wastes.

### 2. Alternative 2 - NEPA No Action

This alternative includes all monitoring, maintenance, and access control actions currently implemented at the site. This alternative is equivalent to the "No Action" alternative required by NEPA. These actions are designed to protect human health and the environment by accomplishing the following:

- Restriction of public access to the site

- Prevention of deterioration of existing containment structures
- Characterization of the culvert
- Monitoring of distribution and potential migration of plutonium and americium on-site and off-site including the ponding area adjacent to Route 539 and the culvert below the road, and
- Prevention of disturbance of the site.

These goals would be accomplished through implementation of the following actions:

- Installation and maintenance of fencing and signs, including fencing of the ponded area
- Monthly visual inspections
- Maintenance of concrete apron
- Annual radiological surveys
- Maintaining government control of the site.

Fencing and signs. Fencing and signs would be used to preclude access by the public. Fences would be 6 feet in height, topped with barbed or concertina wire. Appropriate warning signs ("No Trespassing" and radiological hazard signs) would be posted on the fence at 50-foot intervals.

In order to encircle the site, 4,750 linear feet of fence added to the existing 2,200 linear feet of fence installed during the RI, and 100 no trespassing/radiological hazard signs would be posted.

Monthly visual inspections. Monthly visual inspections would be used to document site conditions. The condition of fencing and signs would be inspected to ensure site security. Evidence of site entry would be noted. The condition of contaminated media would be inspected, and evidence of deterioration or damage would be noted. Corrective actions would be recommended and carried out if conditions warranted.

Maintenance of concrete apron. Maintenance of concrete apron would be performed on an as-needed basis. The cement overlayer would be patched and repaired as required. Asphalt would be sealed and plants removed on a routine annual basis.

Maintenance operations would generate an estimated two (2) 55-gallon drums of low-level radioactive waste (average activity less than 100 nanoCuries/gram (nCi/g)) annually that would required disposal.

Annual radiological surveys. Annual radiological surveys would be conducted to verify that contaminants are not migrating off-site. Surveys would be conducted annually for 5 years and at 5-year intervals thereafter. This requires development of a sampling plan that is sufficient to make this verification. Annual sampling would include on-site selected ground water wells, stream sediments in the site drainage pathway, and soils both on-site and off-site. Sampling techniques would include a combination of sample collection/laboratory analysis and in-situ survey techniques.

1) Sampling of 10 on-site ground water monitoring wells - 10 person-days.
2) Collection of 20 sediment and 40 soil samples from near-site locations - 10 person-days.
3) FIDLER surveys of near-site locations - 10 person-days.
4) Analysis and write-up of results - 20 person-days.

It is estimated that four (4) 55-gallon drums of potentially radioactive (less than 100 nCi/g) of wastes requiring disposal would be generated annually.

Maintaining government control of the site. Maintaining government control of the site would be used to ensure that contaminated media are not disturbed in the future. If the government maintains possession of the site, deed restrictions would not be necessary. In order to release the property, the government would have to certify that all remedial actions necessary to protect human health and the environment have been taken.

Under this alternative, concentrations of contaminants present in soils, sediments, concrete, asphalt, and structures would not be reduced, and the risk to the hypothetical maximally-exposed individual (HMEI) would remain at $1.3 \times 10^{-3}$, a level considered unacceptable. However, this alternative would mitigate risk by preventing access to the site by the HMEI, thereby eliminating the only exposure scenario that presents unacceptable risk. This alternative, therefore, is protective of human health and the environment. The lifetime excess cancer risk to off-site receptors is estimated to be well below the level considered acceptable.

### 3. Alternative 3 - Limited Action

This alternative includes all monitoring, maintenance, and access control actions currently implemented at the site, plus removal and Off-site Disposal of a limited amount of potentially contaminated materials. Specifically, additional actions include excavation of geophysical anomalies detected on-site that may represent the missile launcher from Shelter 204, and proper Off-site Disposal of any contaminated materials (launcher, associated hardware, contaminated soils) discovered. These actions are designed to protect human health and the environment by accomplishing the following:

1) Restrict public access to the site.
2) Prevent deterioration of existing containment structures.
3) Monitor distribution and potential migration of plutonium and americium on-site and off-site.
4) Prevent disturbance of the site.
5) Locate and remove the missing missile launcher, if possible.

These goals would be accomplished through implementation of the following actions:

- Installation and maintenance of fencing and signs
- Quarterly visual inspections
- Maintenance of concrete apron

- Annual Radiological Surveys
- Maintaining government control of the site
- Excavation and Disposal of Missile Launcher.

Fencing and signs. Fencing and signs would be used to preclude access by the public. Fences would be 6 feet in height, topped with barbed or concertina wire. Appropriate warning signs ("No Trespassing" and radiological hazard signs) would posted on the fence at 50-foot intervals.

In order to encircle the site, 4,750 linear feet of fence added to the existing 2,200 linear feet of fence installed during the RI, and 100 no trespassing/radiological hazard signs would be required.

Quarterly visual inspections. Quarterly visual inspections wold be used to document site conditions. The condition of fencing and signs would be inspected to ensure site security. Evidence of site entry would be noted. The condition of contaminated media would be inspected, and evidence of deterioration or damage would be noted. Corrective actions would be recommended and carried out if conditions warranted.

Maintenance of concrete apron. Maintenance of concrete apron would be performed on an as-needed basis. The cement overlayer would be patched and repaired as required. Asphalt would be sealed and plants removed on a routine annual basis.

Maintenance operations would generate an estimated two (2) 55-gallon drums of low-level radioactive waste (average activity less than 100 pCi/g) annually that would required disposal.

Annual radiological surveys. Radiological surveys would be conducted to verify that contaminants were not migrating off-site. Surveys would be conducted at 5-year intervals. This would require development of a sampling plan that is sufficient to make this verification. Sampling would include on-site selected ground water wells, stream sediments in the site drainage pathway, and soils both on-site and off-site. Sampling techniques would include a combination of sample collection/laboratory analysis and in-situ survey techniques.

It is estimated that four (4) 55-gallon drums of potentially radioactive (less than 100 pCi/g) of wastes requiring disposal would be generated annually.

Maintaining government control of the site. Maintaining government control of the site would be used to ensure that contaminated media are not disturbed in the future. If the government maintains possession of the site, deed restrictions would not be necessary. In order to release the property, the government would have to certify that all remedial actions necessary to protect human health and the environment have been taken.

Missile launcher. The location of the missile launcher is currently unknown. A geophysical survey was conducted during the RI for the purpose of locating the missile launcher. The results of the geophysical survey indicated that five magnetic anomalies that could represent the missile launcher exist on or adjacent to the BOMARC site. In order to determine if the anomalies do represent the missile launcher, excavation and visual inspection would be required.

Assuming that the launcher is found, additional actions would be required. At present, the level of radioactivity and size/shape of the launcher are unknown. The intense heat associated with the fire in Shelter 204 may have partially melted or deformed the launcher. The total weight of the launcher is estimated at 2 to 3 tons, and the length is 30 feet. The launcher may have to be sectioned to facilitate removal and transport. Since the launcher may be contaminated and the degree of contamination is unknown, the launcher would have to be surveyed with appropriate radiological survey equipment in order to document the degree of contamination.

Due to the possibility that soils surrounding the launcher may be contaminated, soils would be sampled and containerized pending receipt of results of sample analysis at a permitted low-level radioactive waste facility.

After the launcher and surrounding soils have been characterized with respect to radioactivity, they would be excavated, consolidated for transport, and trucked off-site for disposal. All excavated areas would be restored to original grade, covered with topsoil, and re-planted with species indigenous to the New Jersey Pinelands.

Under this alternative, concentrations of contaminants present in soils, sediments, concrete, asphalt, and structures would not be reduced, and the risk to the hypothetical maximally-exposed individual (HMEI) would remain at $1.3 \times 10^{-3}$, a level considered unacceptable. However, this alternative would mitigate risk by preventing access to the site by the HMEI, thereby eliminating the only exposure scenario that presents unacceptable risk. This alternative, therefore, is protective of human health and the environment. The lifetime excess cancer risk to off-site receptors is estimated to be well below $1 \times 10^{-6}$, the level considered acceptable.

### 4. Alternative 4 - On-site Treatment

On-site Treatment involves physical removal of plutonium and americium from contaminated media on-site, concentration of radioactive wastes, and shipment of concentrated wastes off-site for disposal at a permitted low-level radioactive waste facility. Treated materials would be redeposited on-site. There is a possibility that the missile launcher, if found, would require Off-site Disposal without treatment, depending on the condition of the launcher, technical feasibility of decontamination, and level of radioactivity. Since different technologies would be used to treat different contaminated media, the approach for treatment of each contaminated medium within the context of the On-site Treatment Alternative is given below:

Soils would be treated using the TRU-Clean[R] process, or a similar process. The TRU-Clean[R] process has been demonstrated to reduce plutonium and americium concentrations in soils. This process has been tested on soils from the BOMARC site with favorable results.

This alternative would require the excavation of an estimated 6,200 cubic yards of soil. In order to excavate contaminated soils in the asphalt drainage ditch, the asphalt cover would be removed and disposed of as low-level radioactive waste. The estimated volume of asphalt to be removed from the drainage ditch is 124 cubic yards, using an expansion factor of 2.0.

Treatment processes would be conducted indoors so that wastes are protected from wind and water erosion and effectively contained. A process building approximately 20,000 square feet in area, consisting of slab-on-grade construction, steel superstructure, and corrugated sheet-metal roof and walls would be appropriate. A blower system would be installed to maintain negative air pressure inside the structure, and air would be exhausted through high-efficiency particulate air (HEPA) filters in order to control any potential fugitive dust emissions. Within this structure, a secure area for stockpiles would have concrete floors sloped to sumps to facilitate collection of leachate, and would be surrounded by concrete curbs designed to contain run-on/run-off. A similarly contained area would be constructed and designated for storage of concentrated waste residuals awaiting off-site shipment.

Additional facilities required include a concrete decontamination pad for heavy equipment used in excavation activities. The pad would be approximately 800 square feet in area, sloped to a collection sump, and surrounded by concrete curbing for containment. Decontamination water would be filtered and recycled in order to minimize generation of wastewater requiring disposal.

It is conservatively estimated that approximately 1,860 cubic yards of concentrated wastes (contaminated soils) would be generated by the TRU-Clean process. This equates to approximately 70% volume reduction. These wastes would require Off-site Disposal as low-level radioactive waste.

Environmental monitoring would be conducted during soil excavation and treatment activities. Continuous air sampling would be conducted during intrusive activities such as excavation. A network of four to six high-volume air samples would be used to monitor for radioactive particulates. The air samplers are used to draw large volumes of air through filters, and the filters would be analyzed for alpha activity in the field daily. If air filter analysis indicated resuspension of plutonium and/or americium, corrective measures such as spraying the soil with water would be implemented to minimize resuspension. Air sampling data collected during intrusive sampling activities of the RI do not indicate that resuspension of radionuclides pose a serious problem.

Surface water sampling also be conducted during storm/runoff events, in order to ensure that contaminated sediments are not leaving the site via the surface water pathway.

Concrete apron. Concrete apron materials would be physically decontaminated using a suite of mechanical abrasion technologies. This would be accomplished by sectioning the concrete into manageable-sized pieces of a few square feet each, and removing/segregating the layer of asphalt beneath the concrete. The asphalt, which contains most of the associated radioactivity on its upper surface, would be containerized for Off-site Disposal as a low-level radioactive waste. The asphalt cannot be decontaminated due to presumed insufficient structural integrity to withstand the physical decontamination techniques under consideration. An estimated 356 cubic yards of asphalt requiring disposal as a radioactive waste would be generated. An estimated 22,500 square feet of concrete, 4 to 6 inches thick and contaminated primarily on the lower surface would require decontamination.

Sectioning of concrete would be done outdoors under strict engineering controls designed to prevent resuspension of contaminated particulates. If water or other fluids are used to lubricate or cool sectioning equipment, the fluids would be collected and/or contained. If dust or particulates are generated, a vacuum blower would be used to direct the dust through a HEPA filter to capture the particulates. Air samplers would be placed to monitor sectioning activities.

After separation of asphalt from concrete, sectioned pieces of concrete would undergo decontamination. The concrete would be decontaminated using mechanical abrasion technologies. The same building used to house the TRU-Clean[R] process would be used to house the decontamination process for structural materials. The building would consist of a concrete slab on-grade with steel superstructure and corrugated sheet metal walls and roof. The building would be approximately 20,000 square feet in area. The floor would have concrete curbing to prevent run-on/run-off, and would be sloped to a collection sump to facilitate the removal of any liquids. The building would be maintained under negative air pressure during working hours, with exhaust vented through HEPA filters.

The decontamination process would generate an estimated 25 cubic yards of low-level radioactive waste requiring disposal.

Following decontamination, sectioned concrete would be surveyed on-site for radioactivity. Concrete found to be contaminated above the release limits given in Table 5 would be either reprocessed or disposed of as low-level radioactive waste. Concrete found to be below the release limit would be left on-site.

Shelter 204. Shelter 204 would be processed in the same manner as the concrete apron, with a few exceptions. The steel structural components of the shelter would require a different sectioning method, such as cutting with a torch. Wipe sample results from the RI indicate that most of the shelter, with the exception of the floor, is largely uncontaminated. Therefore, most of the shelter would be sectioned, scanned for radioactivity, and returned to the site with no decontamination required. Metal components of Shelter 204 requiring decontamination would be decontaminated using abrasive blasting because scarification and impaction methods are not effective on metal surfaces. Concrete components, especially the shelter floor, may require a different sectioning technique than the concrete apron, due to greater amounts of steel reinforcing bars in the concrete and thicker concrete. Soil in the launcher pit would be removed and addressed with other contaminated soils through use of the TRU-Clean process.

The original floor of Shelter 204 is covered by approximately 6 inches of concrete, poured contemporaneously with the concrete apron. Both the upper and lower surfaces of this layer are contaminated. In addition, the upper surface of the original floor is also contaminated. Therefore, the total surface area of floor materials requiring decontamination (assuming that the two slabs of concrete can be separated) is three times the total floor area (1,380 square feet) or 4,140 square feet.

An estimated 25 percent of the total area of the interior concrete walls would require decontamination. This equates to 516 square feet. An estimated 25 percent of steel structural materials would require decontamination; this equates to 604 square feet.

An estimated 10 cubic yards of radioactive wastes would be generated by decontamination operations conducted on Shelter 204 structural materials.

Utility bunkers. Utility bunkers would be excavated and removed from the ground after the concrete apron has been removed. Utility bunkers are constructed of concrete, and are box-shaped with dimensions of 6 ft × 4 ft × 6 ft. Total interior surface area of each bunker is 331 square feet, an estimated 50 percent of which would require decontamination. The concrete would be sectioned and decontaminated using mechanical abrasion technologies. Concrete would be decontaminated using the same facilities and engineering controls described for the concrete apron. An estimated 2 cubic yards of low-level radioactive waste requiring disposal would be generated.

Missile launcher. The missile launcher would be located, excavated, and hauled to the on-site physical decontamination facility. Once the launcher is prepared for processing, it would be decontaminated by abrasive blasting. It is estimated that 100 percent of the surface area of the launcher would require decontamination. Total surface area of the launcher is estimated at 396 square feet.

Disposal contingency. It is possible that some of the structural materials proposed for physical decontamination (all contaminated media except soils) cannot be effectively decontaminated using available technologies. This is due to the possibility that radionuclides have migrated below the surface of the structural materials (especially concrete) thereby preventing effective decontamination by removal of surficial contamination. If this is the case, these materials would be disposed of in a permitted off-site low-level radioactive waste facility. Structural materials would first be separated into contaminated and "clean" fractions by on-site radiological surveys followed by sectioning of contaminated portions of the materials. "Clean" fractions would be left on-site.

It is also possible that soils in the drainage ditch south of Shelter 204, which were treated with motor oil, cannot be effectively treated, and would require Off-site Disposal.

All areas excavated would be restored to original grade, covered with topsoil, and replanted with species indigenous to the New Jersey Pinelands.

Under this alternative, concentrations of contaminants present in soils, sediments, concrete, asphalt, and structures would be reduced, and the life time cancer risk to the HMEI would be less than $1\times10^{-4}$, a level considered acceptable. This alternative, therefore, is protective of human health and the environment. This lifetime excess cancer risk to offsite receptors is estimated to be well below the level considered acceptable.

### 5. Alternative 5 - Off-site Disposal

Under this alternative, all contaminated media would be removed from the site and transported off-site for disposal. Permitted Off-site Disposal facilities considered in the FS as representative of commercially-operated and government-operated facilities included the U.S. Ecology facility in Hanford, Washington, and the U.S. DOE Nevada Test Site, respectively.

Different environmental media would be handled and packaged differently, with the common goal of utilizing on-site radioanalysis to limit the total amount of wastes designated for disposal as radioactive waste by separating "clean" materials from contaminated materials to the maximum extent possible. For example, on-site analysis would be used to scan concrete from Shelter 204 and the concrete apron prior to final sectioning. Contaminated portions would then be sectioned away from uncontaminated portions for separate disposal.

Handling procedures for each contaminated medium are described below:

Soil. Soil would be excavated using conventional excavation equipment. Continuous air monitoring would be performed in work areas, and engineering controls for dust suppression such as spraying the soil with water would be implemented. An estimated 6,200 cubic yards of soil would be excavated from the site. Soil would be containerized on-site, loaded onto trucks, and trucked to one of the two disposal sites mentioned above.

Concrete/asphalt apron. Concrete/asphalt apron would be sectioned, scanned with a FIDLER instrument, and containerized for transport off-site. Transportation would be by truck to a permitted off-site radioactive waste facility. Total volume to be disposed is 938 cubic yards, assuming an expansion factor of 2.0.

All demolition activities would have engineering controls designed to minimize resuspension, and all activities would be monitored using high volume air samplers. Concrete found to be uncontaminated would be left on-site.

In addition, approximately 124 cubic yards of asphalt covering contaminated soils in the drainage ditch require excavation and disposal.

Shelter 204. Shelter 204 would be sectioned, scanned with a FIDLER instrument, and containerized for off-site transport. Transportation would be by truck to one of the two disposal sites mentioned above. All demolition activities would be monitored using high volume air samplers. Engineering controls designed to minimize resuspension would be utilized. The total volume of waste materials to be disposed of is estimated at 402 cubic yards. Materials found to be uncontaminated would be left on-site.

Utility bunkers. Utility bunkers would be excavated sectioned, scanned with a FIDLER instrument and containerized on-site. Total volume requiring disposal as radioactive waste is 37 cubic yards. Materials found to be uncontaminated would be left on-site.

Missile launcher. The missile launcher would be excavated as described previously. The entire launcher, having an estimated volume of 5 cubic yards and an estimated weight of 2-3 tons would require sectioning and disposal. An estimated 100 cubic yards of contaminated soils would also be associated with the launcher and would require disposal.

All areas excavated would be restored to original grade, covered with topsoil, and replanted with species indigenous to the New Jersey Pinelands.

Under this alternative, concentrations of contaminants present in soils, sediments, concrete, asphalt, and structures would be reduced, and the life time cancer risk to the HMEI would be less than $1\times10^{-4}$, a level considered acceptable. This alternative, therefore, is protective of human health and the environment. This lifetime excess cancer risk to offsite receptors is estimated to be well below the level considered acceptable.

C. ARARs in the Description of Alternatives

### 1. Cleanup Standards

There are currently no applicable cleanup standards for soils, concrete, asphalt, or other structural materials at the BOMARC site. However, there are standards "to be considered" (TBCs) in cleanup of the site, as follows:

Surface Contamination Standards. At the present time, no promulgated standards exist for radionuclide surface contamination at an unlicensed facility. In lieu of applicable standards, residual radionuclide surface contamination limits for BOMARC equipment and structures are adopted from NRC guidelines which are materials "to be considered" (TBCs). These limits are those in NRC's regulatory Guide 1.86 (NRC 1974), which for transuranics are: 100, 300, and 20 disintegrations per minute from an area of 100 square centimeters for average, maximum, and removable contamination, respectively.

Fuel Cycle Standards. Although not ARARs for Department of Defense (DoD) activities, the U.S. EPA regulations in 40 CFR 190, "Environmental Radiation Protection Standards for Nuclear Power Operators," bear on radiation in the environment and contain TBCs. These regulations state that: "Operations shall be conducted in such a manner as to provide reasonable assurance that: (a) The annual dose equivalent does not exceed 25 mrems to the whole body, 75 mrems to the thyroid, and 25 mrems to any other organ as the result of exposures to planned discharges of radioactive materials, radon and its daughters expected, to the general environment from uranium fuel cycle operations and to radiation from these operations."

### 2. Action-Specific Requirements

The Low Level Radioactive Waste Policy Amendments Act (LLRWPAA) takes effect in 1993. The LLRWPAA directs states to form compacts for the purposes of low-level radioactive waste disposal. Under the LLRWPAA, member states develop disposal sites within compact borders for compact member use. When the LLRWPAA takes effect in January 1993, compact states can elect to refuse acceptance of wastes from non-compact states, although non-compact waste shipments are not automatically barred. This has the effect of potentially severely curtailing disposal options for wastes from the BOMARC site, because New Jersey does not belong to a compact with a licensed disposal facility.

Other action-specific requirements associated with Off-site Disposal of wastes include those stated in 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste." These regulations set standards for disposal facilities, and preclude any commercial disposal site from accepting wastes containing over 100 nCi/g of alpha-emitting radionuclides such as plutonium and americium. In addition, the DOE's Nevada Test Site cannot currently accept wastes with over 100 nCi/g of activity, due to institutional constraints imposed by the state of Nevada (Johnston, 1991).

Management or treatment of contaminated soils and structural materials at the BOMARC site might include access and institutional controls, containment, On-site Treatment, or removal. Treatment or Off-site Disposal of wastes could require one or more permits. Action-specific requirements may include meeting the requirements of, and might possibly include acquiring permits under, the following regulations:

- 40 CFR 52, 60, and 61. Air Quality Regulations: Prevention of Significant Deterioration (PSD) and National Emission Standards for Hazardous Air Pollutants (NESHAP). Both a NESHAP and PSD authorization could be required. Also, best available control technology (BACT) could be required. Radionuclides are no longer PSD affected pollutants; however, other types of emissions could be affected.

## C. Location-Specific Requirements

Since the BOMARC site is located in the New Jersey Pinelands, regulations governing the Pinelands apply. Specifically, the New Jersey Regional Low-level Radioactive Waste Disposal Facility Siting Act (the Act) of 1987 prohibits establishment of low-level radioactive waste disposal facilities in the Pinelands. The Pinelands Comprehensive Management Plan (Section 7:50 - 6.77) states that "No hazardous, toxic, chemical, petroleum, septic, or nuclear waste shall be stored, discharged, or disposed of on any land within the Pinelands."

Location-specific requirements affect the cleanup actions that can be taken at a given site because of the impact those actions might have on characteristics of the site other than the existence of hazardous substances. In effecting a cleanup, it is necessary to meet the requirements of the following regulations related to historic preservation and species protection:

- 36 CFR 800, 25 CFR 261, 43 CFR 3, and 43 CFR 7, Historic Preservation Regulations. Requirements of the National historic preservation Act in 36 CFR 800, the American Antiquities Act in 25 CFR 261 and 43 CFR 3, and the Archaeological Resources Protection Act and the American Indian Religious Freedom Act in 43 CFR 7 apply to the protection of historic and cultural properties, including both existing properties and those discovered during excavation or construction.

- 50 CFR 10-24 and 50 CFR 402. Species Protection Regulations. Regulations of the Endangered Species Act, the Bald and Golden Eagle Protection Act, and the Migratory Bird Treaty Act in 50 CFR 10-24 and 50 CFR 402 apply to the protection of these species at all times.

## VII. SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The remedial alternatives for the BOMARC Missile Site were compared according to nine criteria developed on the basis of statutory requirements of CERCLA Section 121 and the NCP. The nine criteria are subdivided into three categories: (1) threshold criteria which relate directly to statutory findings and must be satisfied by each chosen alternative; (2) primary balancing criteria, which include technical factors such as the long and short term effectiveness, implementability, reduction of toxicity, mobility, and volume, and cost; and (3) modifying criteria, which are measures of the acceptability of the alternatives to state agencies and the community. The following sections summarize the evaluation of the candidate remedial alternatives according to these criteria. Table 6 includes a summary of the comparative analysis, or relative ranking, of the alternatives.

## A. Threshold Criteria

### 1. Overall Protection of Human Health and the Environment

This criterion measures how the alternative, as a whole, achieves and maintains protection of human health and the environment. On-site Treatment and Off-site Disposal Alternatives provide the highest degree of protection of human health and the environment. These alternatives reduce the potential for contaminants to migrate from the site, and benefit human health and the environment by removing contaminants from the site. Although both alternatives have the potential for adverse effects during the construction or treatment phase of cleanup, these adverse effects can be mitigated, and are outweighed by the benefits of permanently reducing the source of contamination. NEPA No Action and Limited Action Alternatives provide for a somewhat reduced level of protection of human health by restricting access and the potential for on-site exposure. Since on-site exposure is the only scenario that presents unacceptable risk, these two alternatives would lower risks to acceptable levels. Unrestricted Access Alternative offers an unacceptable level of protection of human health and the environment.

### 2. Compliance with ARARs

Compliance with ARARs is a consideration of how the alternatives comply with regulations that explicitly apply to the site and those regulations that are sufficiently relevant to warrant inclusion. In some extenuating situations, waivers from selected ARARs may be obtained. However, no waivers are being sought.

## Table 6
## Summary of Comparative Analysis of Remedial Alternatives

| Remedial Alternatives | Technical Analysis | Environmental Analysis | Public Health Analysis | Institutional Analysis | Cost Analysis |
|---|---|---|---|---|---|
| Unrestricted Access | ○ | ○ | ○ | ○ | ● |
| Existing Conditions | ◑ | ◑ | ◕ | ◕ | ◕ |
| Limited Action (Nevada Test Site Disposal) | ◑ | ◑ | ◕ | ◑ | ◕ |
| Limited Action (Hanford, Washington Disposal) | ◔ | ◑ | ◕ | ◔ | ◕ |
| Onsite Treatment (Nevada Test Site Disposal) | ◑ | ◕ | ● | ◑ | ◑ |
| Onsite Treatment (Hanford, Washington Disposal) | ◑ | ◕ | ● | ◔ | ◔ |
| Offsite Disposal at Nevada Test Site | ◕ | ◕ | ● | ◑ | ◑ |
| Offsite Disposal at Hanford, Washington | ◕ | ◕ | ● | ◔ | ○ |

Legend:

- ● Most Favorable
- ◕
- ◑
- ◔
- ○ Least Favorable

On-site Treatment and Off-site Disposal Alternatives achieve health-based and regulatory-based cleanup goals. Although neither NEPA No Action nor Limited Action Alternatives meet these same cleanup goals, these goals apply only if unrestricted access to the site is allowed. However, access is restricted under these two alternatives, so these cleanup goals do not apply. Unrestricted Access Alternative does not achieve cleanup goals or reduce risk by any means.

## B. Primary Balancing Criteria

### 1. Long-term Effectiveness and Permanence

This criterion evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after remedial action objectives have been met.

On-site Treatment and Off-site Disposal Alternatives provide the greatest degree of long-term effectiveness because wastes contaminated above cleanup criteria are removed from the site and placed in a facility designed for management of long-lived radioactive wastes. NEPA No Action and Limited Action Alternatives are not as effective over the long-term because both leave contaminated materials in place and rely on access restrictions to prevent exposure. Due to the extremely long half-life of the site wastes, access controls may be difficult to guarantee over the long period that the waste remains hazardous. Unrestricted Access Alternative is least effective over the long-term.

### 2. Reduction of Toxicity, Mobility, or Volume of Wastes

Alternatives were also evaluated according to their ability to reduce toxicity, mobility, or volume of contaminants through treatment. On-site Treatment is the only alternative that reduces toxicity, mobility, or volume of wastes, since it is the only alternative that includes some form of treatment. The remaining alternatives, including Off-site Disposal Alternative, do not satisfy this preference.

### 3. Short-term Effectiveness

This criterion addresses the effects of the alternatives during the construction and implementation phase until remedial action objectives are met.

The NEPA No Action and the Limited Action Alternatives provide greater short-term effectiveness because they can be implemented more rapidly than the other alternatives, and provide for minimal disturbance of the site. The On-site Treatment and the Off-site Disposal Alternatives are both less effective in the short-term, and the Unrestricted Access Alternative is least effective because risks are not mitigated under this alternative.

### 4. Implementability

This criterion addresses the technical and administrative feasibility of implementing the alternatives and the availability of services and materials required during implementation.

Due to their more complex nature, On-site Treatment and Off-site Disposal Alternatives present more challenges in terms of implementability than the Existing Conditions (#2), Limited Action (#3), and Unrestricted Access (#1) Strategies. Of the two permanent source controls (#4, #5), Off-site Disposal Alternative is technically most easily implemented, due to uncertainties associated with implementation of On-site Treatment Alternative, including process efficiency and effectiveness and difficulties associated with treating soils contaminated with motor oil. Administratively, Limited Action, On-site Treatment, and Off-site Disposal Alternatives may be difficult or impossible to implement after January 1, 1993. On that date, provisions of the Low-level Radioactive Waste Policy Amendments Act (the Act) take effect. Provisions of the Act may preclude interstate shipment and disposal of radioactive wastes at commercial disposal facilities, and the Air Force has not yet received confirmation of availability for disposal at a federal government facility.

### 5. Cost

Cost is another criteria by which candidate alternatives are compared. Costs in this case are measured as capital, operation and maintenance (O&M), and present net worth costs for a 30-year period of performance.

Since Unrestricted Access Alternative would eliminate all existing controls and restrictions, no costs are involved. Unrestricted Access Alternative is closely followed by NEPA No Action and Limited Action Alternatives, respectively, in terms of cost. The two active restoration alternatives (On-site Treatment and Off-site Disposal Alternatives) are the most costly alternatives. The choice of disposal sites for wastes generated (a U.S. DOE site vs. a commercial site in Hanford, Washington) greatly influences the cost of each alternative, since disposal at a government-operated site is much less costly. The least costly active restoration alternative is Off-site Disposal Alternative with disposal at a U.S. DOE disposal facility, followed by On-site Treatment Alternative with disposal at a U.S. DOE site and On-site Treatment Alternative with disposal at a commercial facility in Hanford, Washington, respectively. The most costly alternative is Off-site Disposal Alternative with disposal at the commercial Hanford, Washington facility.

## C. Modifying Criteria

Modifying criteria are used in the final evaluation of the remedial alternatives, and include comment from State Agencies and from the public.

### 1. State Acceptance

The NJDEPE concurs with Off-site Disposal as the preferred alternative. However, NJDEPE does not concur with the Air Force conclusion that additional groundwater monitoring is not necessary. NJDEPE also does not concur with the cleanup level specified in the final EIS and RI/FS that was previously negotiated with the NJDEPE and the U.S. EPA. The Air Force has coordinated the design of a groundwater monitoring program and the development of an appropriate cleanup standard on multiple occasions during the 2 year RI/FS - EIS study process and will adhere to the previously understood agreement. The Air Force's reasons for adhering to previously negotiated cleanup levels are further elaborated in the responsiveness summary.

### 2. Community Acceptance

Based on verbal comments received during the public meeting held June 20, 1992, and written comments received during the comment period ending July 15, 1992, the community appears to accept the preferred remedial alternative. Specific responses and comments to the remedial alternatives may be found in the attached Responsiveness Summary.

## VIII. THE SELECTED REMEDY

Based on the RI and Risk Assessment, no remedial action is necessary for surface water or groundwater to ensure protection of human health and the environment.

The selected remedy - Off-site Disposal at a U.S. DOE radioactive waste disposal facility - will address risks posed by contaminated soils, concrete, asphalt, and structures. Risks from these wastes will be addressed through permanent source removal and disposal in a facility designed for management of long-lived radioactive wastes.

### A. Major Components of the Selected Remedy

The major components of the selected remedy include:

- Excavation of source soils containing greater than 8 pCi/g of plutonium. This will limit maximum risk to any future resident of the site to a level of less than one in 10,000 excess cancer risk, a level considered acceptable.

- Excavation and sectioning of contaminated portions of the concrete apron, utility bunkers, and the missile shelter.

- Excavation and removal (if found) of the missile launcher.

- Containerization, transport, and disposal of radioactive materials in an off-site licensed U.S. DOE facility designed for long-term management of radioactive materials.

- Restoration of the site by backfilling with clean fill as needed, followed by grading and revegetation of the site with indigenous plant species.

- Strict engineering controls to prevent any possible exposures to workers or off-site populations. These include dust suppression, and runoff/sedimentation control measures.

The goal of this remedial action is to restore the site to a condition that will allow unrestricted access by the public. This will be accomplished by removing a sufficient quantity of radioactive wastes from the site such that any remaining wastes will not present an unacceptable risk to human health or the environment. Based on information obtained during the RI and an analysis of remedial alternatives, the Air Force believes that the selected remedy will achieve this goal.

To ensure that cleanup objectives are met, all contaminated media will be sampled during and after remediation. Since contaminants will not remain at the site at levels above cleanup criteria established for the site, long-term monitoring will not be required.

The selection of the preferred alternative is contingent on the condition that Off-site Disposal will remain cost-effective. Current cost estimates documented in the RI/FS indicate that Off-site Disposal at a U.S. DOE site is cost-effective. Should these costs increase to the point that in the judgement of the Air Force, Off-site Disposal is no longer cost-effective, then the NEPA No Action Alternative would be implemented until such time that a cost-effective solution becomes available. The NEPA No Action Alternative is protective of human health and the environment in that it eliminates the only exposure scenario that presents risk - on-site exposure for as long as the Air Force maintains control of the site.

Post-ROD studies required prior to remedial design/remedial action may include depth-discreet soil sampling in the area just west of Shelter 204 and in the area just west of the concrete apron, where the depth of soil contamination requires further definition and waste profile sampling for acceptance of the wastes by the designated disposal facility.

**B. Remedial Action Objectives/Remediation Levels**

The risk assessment concluded that radioactive contamination in soils, concrete, asphalt, and structures presents a threat to human health. The principal threat at the site is to persons entering the site and disturbing wastes found there. Predominant exposure routes are through inhalation of contaminated particulates and ingestion of contaminated soils.

The objective of the remedial action is to restore the site to a condition that will allow unrestricted access by the public. The Air Force will use NEPA No Action as an interim remedy until the Air Force can proceed with excavation and Off-site Disposal of contaminated soils, concrete, asphalt, and structures. Then the site can be restored to risk-based and regulatory-based cleanup levels.

Cleanup levels were developed that are protective of human health and the environment. Residual risks from soils remediated to these levels were evaluated for the hypothetical maximally-exposed individual (HMEI). Relevant exposure pathways included inhalation of contaminated particulates and ingestion of contaminated soils. Results of these analyses indicated that cancer risks to the HMEI will be reduced to approximately $1 \times 10^{-4}$. Non-cancer health effects and risks to off-site receptors are negligible.

Cancer risks to the HMEI will be reduced from the level calculated in the baseline risk assessment (1.3 in 1,000) to approximately 1 in 10,000.

Since the NEPA No Action would result in continued access restrictions at the site, the only resultant public health impact resulting from NEPA No Action would be potential impacts to off-site population. The risk assessment concluded that and those impacts would be negligible.

## IX. THE STATUTORY DETERMINATIONS

The selected remedy meets the statutory requirements of Section 121 of CERCLA, as amended by SARA, and to the extent practicable, the National Contingency Plan.

### A. Protection of Human Health and the Environment

The selected remedy reduces the risk posed by site contaminants through excavation and Off-site Disposal and will attain a $10^{-4}$ to $10^{-6}$ carcinogenic risk. Non-carcinogenic effects for radioactive contaminants will be negligible. The removal of radioactive wastes from the site has the potential for adverse short-term effects if proper engineering controls are not employed; however, engineering controls are readily implemented and will be employed. The interim remedy, NEPA No Action, effectively obviates risk through access restrictions and institutional control.

### B. Attainment of Applicable or Relevant and Appropriate Requirements of Environmental Laws

The selected remedy will comply with all applicable or relevant and appropriate requirements (ARARs) of Federal and State environmental and public health laws. The NEPA No Action remedy also complies with all ARARs.

#### 1. Applicable or Relevant and Appropriate Requirements

Action-Specific

- Low Level Radioactive Waste Policy Amendments Act of 1980
- Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR 61)
- Air Quality Regulations: Prevention of Significant Deterioration (PSD) and National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR 52, 60, 61)

Chemical-Specific

There are no chemical-specific ARARs identified for the BOMARC site.

Location-Specific

- New Jersey Regional Low-level Radioactive Waste Disposal Facility Siting Act of 1987
- Pinelands Comprehensive Management Plan (Section 7:50 - 6.77)
- National Historic Preservation Act (36 CFR 800)
- American Antiquities Act (25 CFR 261 and 43 CFR 3)
- Archaeological Resources Protection Act, American Indian Religious Freedom Act (43, CFR 7)
- Endangered Species Act, Bald and Golden Eagle Protection Act, Migratory Bird Treaty Act (50 CFR 10-24, 50 CFR 402)

**2. To be considered materials**

Surface Contamination Standards. At the present time, no promulgated standards exist for radionuclide surface contamination at an unlicensed facility. In lieu of applicable standards, residual radionuclide surface contamination limits for BOMARC equipment and structures are adopted from NRC guidelines which are materials to be considered (TBCs). These limits are those in NRC's regulatory Guide 1.86 (NRC 1974), which for transuranics are: 100, 300, and 20 disintegrations per minute from an area of 100 square centimeters for average, maximum, and removable contamination, respectively.

Fuel Cycle Standards. Although not ARARs for DoD activities, the U.S. EPA regulations in 40 CFR 190, "Environmentai Radiation Protection Standards for Nuclear Power Operators," bear on radiation in the environment and contain TBCs. These regulations state that: "Operations shall be conducted in such a manner as to provide reasonable assurance that: (a) The annual dose equivalent does not exceed 25 mrems to the whole body, 75 mrems to the thyroid, and 25 mrems to any other organ as the result of exposures to planned discharges of radioactive materials, radon and its daughters expected, to the general environment from uranium fuel cycle operations and to radiation from these operations."

## C. Cost Effectiveness

The Off-site Disposal at a DOE facility is cost-effective and provides overall effectiveness proportionate to its costs and duration for remediation of radioactive contaminants. The NEPA No Action remedy is also cost effective and affords the Air Force an interim remedy should implementation of Off-site Disposal Alternative lose its cost effectiveness. The Air Force with U.S. EPA concurrence feels comfortable with the NEPA No Action Alternative as an interim solution. There are no overriding health risks associated with this alternative as bourne out by the EIS. However, given regulatory requirements such as CERCLA and the Air Force's desire to limit risk to human health and the environment, off-site disposal is still the preferred alternative. The Air Force must continue to balance limited resources with its committment to environmental restoration. While off-site disposal at a DOE disposal site at a cost of $7 million is acceptable, a cost in excess of $24 million for dispolal at a commercial facility does not pass the cost reasonableness test. Currently Congress has appropriated $400 million in Defense Environmental Restoration Account (DERA) funds for FY 93. An additional $108 million is required for other must pay requirements. Cleanup of the BOMARC Missile Accident Site must compete for this limited funding with other DERA projects. With no imminent risk to human health or the $7 million can be justified while the $24 million cannot.

### D. Use of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

The Air Force has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner for the BOMARC Missile Accident Site. The risks posed by radioactive contaminants are permanently reduced by removal of contaminants and disposal in an off-site facility designed for management of long-termed radioactive wastes. The selected remedy provides the best balance of tradeoffs in terms of long-term effectiveness and permanence, reduction in toxicity, mobility, or volume, short-term effectiveness, implementability, and cost. State and community acceptance were also considered. The NEPA No Action remedy would eliminate the only exposure scenario that presents risk. This would provide a permanent solution as long as the Air Force maintains site control.

### E. Preference for Treatment as Principal Element

Off-site Disposal of radioactive wastes does not satisfy the statutory preference for treatment as a principal element. Due to waste types and site conditions that make treatment problematic, Off-site Disposal best satisfies the nine CERCLA evaluation criteria used for alternative selection.

## X. DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for The BOMARC Missile Accident Site was released for public comment in May 1992. The Proposed Plan identified Off-site Disposal Alternative, as the preferred alternative. Upon review of public comment, it was determined that no significant changes to the remedy, as it was originally identified in the Proposed Plan, were necessary. The Air Force has however elaborated on adoption of the interim No Action Alternatives, as was requested in several comments.