

**U.S. Department of Energy**

**Radionuclide Air Emissions  
Annual Report**

**Calendar Year 1996**

**Rocky Flats Environmental  
Technology Site**

**ORIGINAL**

**U.S. Department of Energy**

**Radionuclide Air Emissions Annual Report  
for Calendar Year 1996**

*Prepared in accordance  
with 40 CFR 61, Subpart H  
and  
Regulation No. 8, Part A, Subpart H*

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## **EXECUTIVE SUMMARY**

As required by Title 40 of the Code of Federal Regulations, Part 61, Subpart H and Colorado Air Quality Control Commission Regulation No. 8, Part A, Subpart H, the radiation dose to the public from the Rocky Flats Environmental Technology Site (Site) is determined annually and reported to the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment. These regulations require that the dose to any member of the public in any calendar year not exceed an effective dose equivalent (EDE) of 10 millirem (mrem).

The 1996 dose was determined using the EPA-approved CAP88-PC dispersion model to simulate transport of emissions from buildings and contaminated soils at the Site. The dose was calculated for the most impacted off-Site resident. The EDE for the 1996 calendar year to the maximally exposed individual was calculated to be 0.182 mrem, which is approximately 1.8% of the standard. Individuals living or working at other off-Site locations received a lower dose.

The health risk associated with 1 mrem of EDE from naturally occurring sources of background radiation (such as uranium or thorium in rock or soil, cosmic rays, and radon emitted from soil or bedrock) is the same as that produced from anthropogenic sources of radiation, such as Site activities. The average annual EDE for residents of the Denver area from other sources of background radiation is greater than 350 mrem.

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## ABBREVIATIONS AND ACRONYMS

<b>Am</b>	Americium
<b>ANSI</b>	American National Standards Institute
<b>Aug</b>	August
<b>Ave</b>	Avenue
<b>Be</b>	Beryllium
<b>Blvd</b>	Boulevard
<b>Bq</b>	Becquerel
<b>CAP88-PC</b>	Clean Air Act Assessment Package-1988 (Version 1.0)
<b>CAQCC</b>	Colorado Air Quality Control Commission
<b>CDPHE</b>	Colorado Department of Public Health and Environment
<b>CERCLA</b>	Comprehensive Environmental Response, Compensation, and Liability Act
<b>CFR</b>	Code Of Federal Regulations
<b>Ci</b>	Curie
<b>cm</b>	Centimeter
<b>CML</b>	Criticality Mass Laboratory
<b>DOE</b>	U.S. Department Of Energy
<b>E</b>	East
<b>EDE</b>	Effective dose equivalent
<b>EIS</b>	Effluent Information System
<b>ENE</b>	East-northeast
<b>EPA</b>	U.S. Environmental Protection Agency
<b>ESE</b>	East-southeast
<b>Feb</b>	February
<b>GIS</b>	Geographic information system
<b>HEPA</b>	High efficiency particulate air (filter)
<b>HQ</b>	Headquarters
<b>H-3</b>	Tritium
<b>Jan</b>	January
<b>Jul</b>	July
<b>kg</b>	Kilogram
<b>km</b>	Kilometer
<b>km<sup>2</sup></b>	Square kilometer
<b>knot</b>	Nautical mile per hour
<b>m</b>	Meter
<b>m<sup>2</sup></b>	Square meter
<b>m<sup>3</sup>, m<sup>^3</sup></b>	Cubic meter

<b>MEI</b>	Maximally exposed individual
<b>mrem</b>	Millirem
<b>m/s</b>	Meters per second
<b>mSv</b>	MilliSievert
<b>N</b>	North
<b>NE</b>	Northeast
<b>NESHAPS</b>	National Emission Standards for Hazardous Air Pollutants
<b>NNE</b>	North-northeast
<b>NNW</b>	North-northwest
<b>NW</b>	Northwest
<b>Nov</b>	November
<b>ODIS</b>	Off-Site Discharge System
<b>pCi</b>	picoCuries
<b>Pu</b>	Plutonium
<b>rem</b>	Roentgen equivalent man
<b>RF</b>	Rocky Flats
<b>RFEDS</b>	Rocky Flats Environmental Data Base System
<b>S</b>	South
<b>SE</b>	Southeast
<b>Sep</b>	September
<b>Site</b>	Rocky Flats Environmental Technology Site
<b>SNM</b>	Special nuclear material
<b>SSE</b>	South-southeast
<b>SSW</b>	South-southwest
<b>St</b>	Street
<b>STP</b>	Sewage Treatment Plant
<b>Sv</b>	Sievert
<b>SW</b>	Southwest
<b>T-2</b>	Trench 2
<b>T-3</b>	Trench 3
<b>T-4</b>	Trench 4
<b>TDU</b>	Thermal desorption unit
<b>TRU</b>	Transuranic
<b>U</b>	Uranium
<b>U.S.C.</b>	United States Code
<b>VOC</b>	Volatile organic compound
<b>W</b>	West
<b>WNW</b>	West-northwest
<b>WSW</b>	West-southwest

y, yr	Year
μCi	MicroCurie
μm	Micrometer
°C	Degrees Celsius

**Meteorological Data Set  
Wind Speed and Stability Class, 1996  
(Continued)**

WIND DIRECTION <sup>a</sup>	STABILITY CLASS	Wind Speed Frequency (%)					
		1.0 to 1.8 (m/s)	1.8 to 3.3 (m/s)	3.3 to 5.4 (m/s)	5.4 to 8.5 (m/s)	8.5 to 11.0 (m/s)	>11.0 (m/s)
ENE	F	0.187	0.270	0.000	0.000	0.000	0.000
E	F	0.235	0.176	0.000	0.000	0.000	0.000
ESE	F	0.236	0.282	0.000	0.000	0.000	0.000
SE	F	0.272	0.353	0.000	0.000	0.000	0.000
SSE	F	0.313	0.388	0.000	0.000	0.000	0.000
S	F	0.420	0.388	0.000	0.000	0.000	0.000
SSW	F	0.365	0.458	0.000	0.000	0.000	0.000
SW	F	0.418	0.482	0.024	0.000	0.000	0.000
WSW	F	0.608	0.505	0.024	0.000	0.000	0.000
W	F	0.461	0.423	0.012	0.000	0.000	0.000
WNW	F	0.532	0.764	0.012	0.000	0.000	0.000
NW	F	0.427	0.564	0.047	0.000	0.000	0.000
NNW	F	0.396	0.564	0.035	0.000	0.000	0.000

<sup>a</sup> Direction represents origin of winds relative to the Site.

## 1.0 INTRODUCTION

The Rocky Flats Environmental Technology Site (Site) is subject to National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities (Title 40 of the Code of Federal Regulations [CFR], Part 61, Subpart H). Regulation 40 CFR 61, Subpart H applies to operations at any facility owned or operated by the U.S. Department of Energy (DOE) that emits radionuclides (other than radon-222 and radon-220) into the air. The standard requires that emissions of radionuclides to the ambient air from the Site not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent (EDE) of 10 millirem (mrem) (0.1 milliSieverts [mSv]). Colorado has incorporated 40 CFR 61, Subpart H by reference as Colorado Air Quality Control Commission (CAQCC) Regulation No. 8, Part A, Subpart H.

Regulation 40 CFR 61, Subpart H, Section 61.94 requires the Site to calculate the EDE for the previous calendar year and to submit this information, along with other data, to the U.S. Environmental Protection Agency (EPA) in an annual report (Regulation No. 8, Part A, Subpart H requires submittal to the Colorado Department of Public Health and Environment [CDPHE]). This report fulfills the reporting requirements of 40 CFR 61.94 and CAQCC Regulation No. 8, Part A, Section 61.94 for the 1996 calendar year.

## 2.0 FACILITY INFORMATION

This section describes the Rocky Flats Environmental Technology Site, lists the radioactive materials used at the Site, and describes the handling and processing that the radioactive materials undergo. New construction or modifications in calendar year 1996 for which construction approval and startup notification were waived per 40 CFR 61.96 and CAQCC Regulation No. 8, Part A, Section 61.96 are also identified in this section. Construction approval and startup notification were not required for any new construction or modifications in 1996.

### 2.1 Site Description

The Rocky Flats Environmental Technology Site is operated by Kaiser-Hill Company, L.L.C., with oversight by the Rocky Flats Field Office of the U.S. Department of Energy. Prior to 1989, the Site fabricated nuclear weapons components from plutonium (Pu), uranium (U), beryllium, and stainless steel. Production activities included metal fabrication and assembly, chemical recovery and purification of process-produced transuranic (TRU) radionuclides, and related quality control functions. Plutonium weapons operations were curtailed at the Site in 1989 due to safety concerns and in February 1992, the Site's weapons production mission was discontinued. The Site is now undergoing decontamination, decommissioning, and cleanup and is moving toward final closure.

The Site occupies an area of 26.5 square kilometers (km<sup>2</sup>) in northern Jefferson County, Colorado, approximately 25.7 kilometers (km) northwest of Denver. The Site is located at approximately 1,829 meters (m) above mean sea level on the eastern edge of a geological bench known locally as Rocky Flats. This bench, about 8.1 km wide in an east-west direction, flanks the eastern edge of the Rocky Mountains.

Over 2.1 million people live within 80 km of the Site. Adjacent land use is a mixture of agriculture, open space, industry, and residential housing. Surrounding communities include the city of Golden to the south of the Site; the cities of Arvada, Broomfield, and Westminster to the east; and the city of Boulder to the north. An area map is shown in Figure 2-1.

The former production facilities are located near the center of the Site within a fenced security area of 1.6 km<sup>2</sup>. The remaining Site area contains support facilities and serves as a buffer zone for former production facilities. A map of the Site is shown in Figure 2-2; a simplified map of the central portion of the Site (the "industrial area") showing the location of the former production facilities is shown in Figure 2-3.



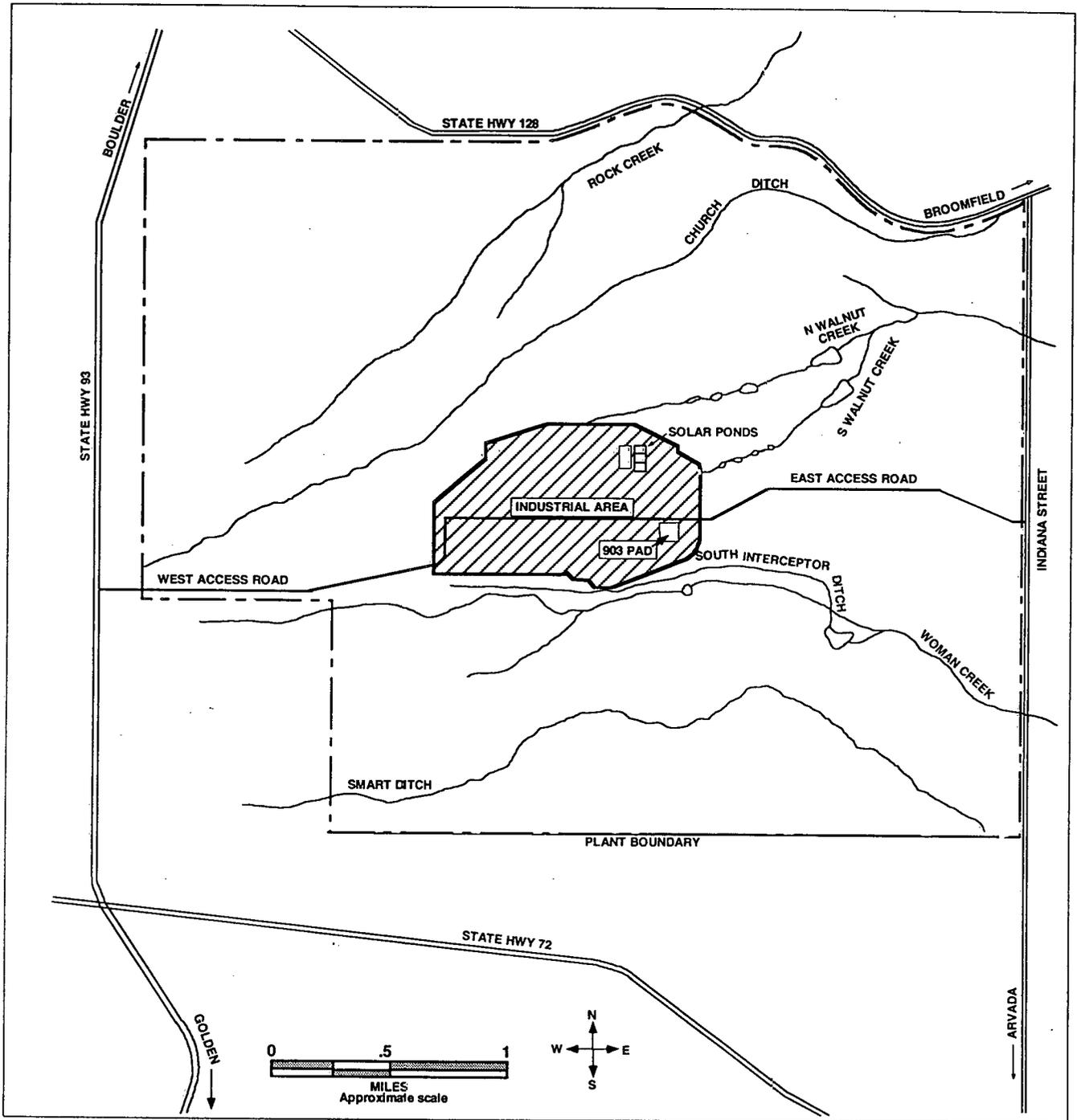


Figure 2-2. Rocky Flats Environmental Technology Site Location Map

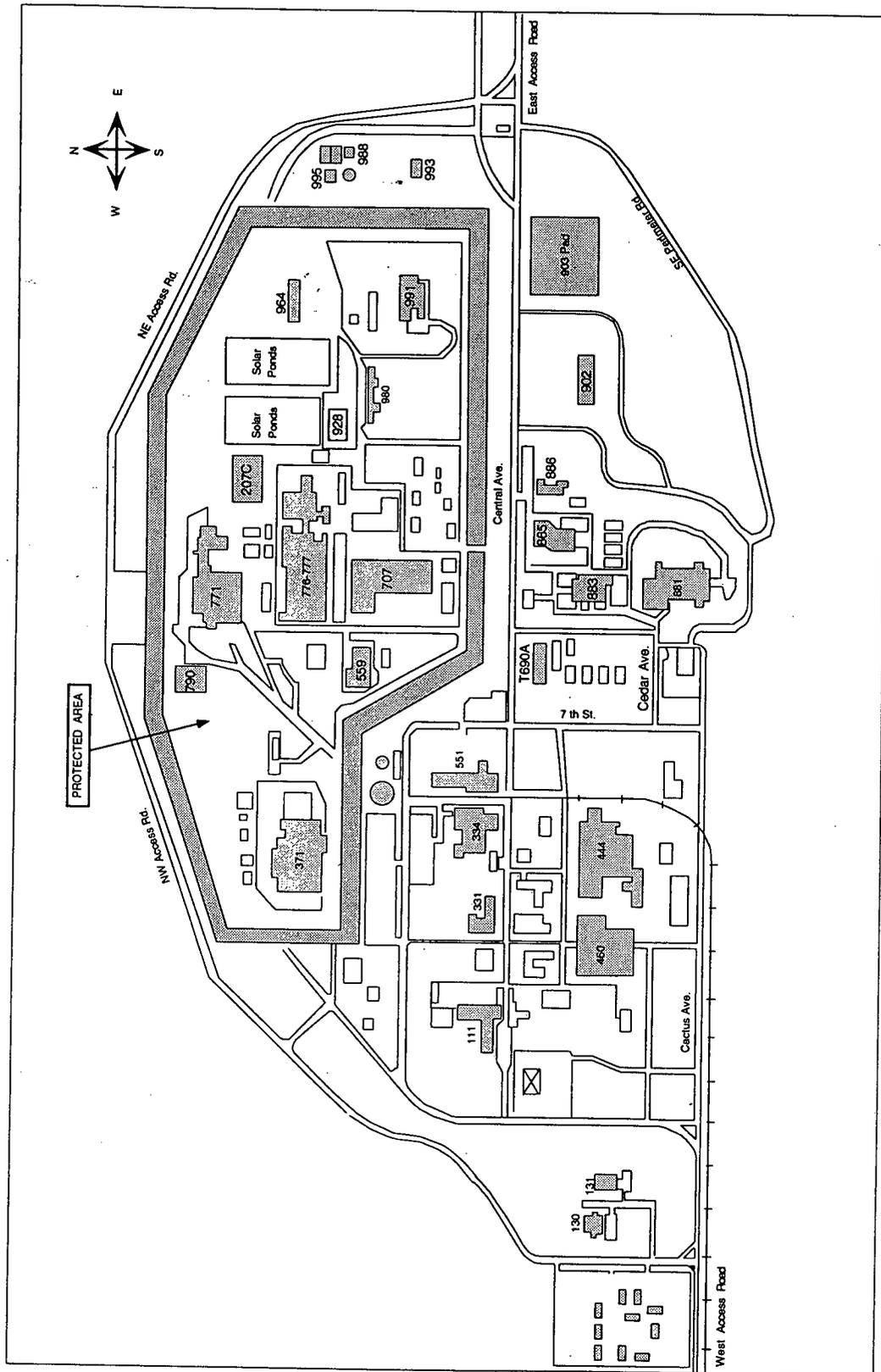


Figure 2-3. Central Portion of the Rocky Flats Environmental Technology Site

The central portion of the Site, which houses the former production facilities, can be roughly divided into halves. The Protected Area, generally located in the northern half of the central area (see Figure 2-3), historically housed plutonium processing operations. The rest of the industrial area was involved with uranium, beryllium, and stainless steel operations.

## **2.2 Radionuclide Air Emissions Source Description**

Radioactive material handling at the Site is currently focused on material consolidation, cleanup, radioactive residue stabilization, waste processing, and analytical operations. Most of the radionuclide air emissions from the Site result from non-point (diffuse) sources, primarily mechanical and natural disturbances of contaminated soil. Soil contamination was caused by past radioactive material spills and other releases.

Radioactive material processing can result in radionuclides becoming entrained in ventilation air (effluent) that is released through vents or stacks (point sources). However, because no routine nuclear weapons-related processing has occurred at the Site since 1989, the majority of radionuclide point source emissions result from the resuspension of residual radioactive material in ventilation systems and from decontamination and deactivation activities taking place in process buildings.

Air exhausted from process buildings is cleaned prior to release by passing it through multiple stages of high efficiency particulate air (HEPA) filters. As a result, radionuclide point source emissions from the Site are very low.

### **2.2.1 Radioactive Materials Handling and Processing in Calendar Year 1996**

In 1996, radionuclide emissions from the Site occurred from a number of activities that either disturbed resident contamination in buildings or in soil, or that processed or used radionuclide-containing substances such that emissions to the atmosphere resulted. Appendix A lists radioactive materials associated with the Site. The list of radionuclides includes Pu-238, Pu-239/240, americium (Am) -241, U-233/234, U-235, U-238, and tritium. The Site also has some small quantities of beta- and gamma-emitting sealed sources and low activity analytical stock solutions, powders, and plated sources; emissions from these sources were negligible.

The major Site activities and sources that handled or processed radionuclides in calendar year 1996, with resulting radionuclide emissions, are described below.

## **Hold-up in Ducts**

Radionuclide emissions were generated through disturbance of contaminant radionuclide dust and other deposits on the surfaces of ventilation ducts exiting process areas. These materials were deposited on duct walls and in rapidly decreasing amounts on the successive stages of HEPA filters during many years of weapons component production. Routine air movement and pressure changes in the ducts entrain a small amount of this contamination on an ongoing basis. In addition, decontamination and equipment removal or reconfiguration activities disturbed a portion of the hold-up in certain ducts in 1996, resulting in additional emissions to the atmosphere. Ducts containing hold-up were vented through multiple stages of HEPA filters.

## **Resident Contamination**

In some process areas, contamination may be found on glovebox surfaces and floors and, in limited cases, in the rooms themselves. This contamination has been surveyed and estimated using surface swipes in the areas. As with hold-up, resident contamination was emitted in 1996 due to routine exposure to ventilation air and due to active disturbance by project activities, particularly decontamination and equipment movement. Ducts venting areas with significant contamination were exhausted through multiple stages of HEPA filters.

## **Waste Handling and Storage**

Packaged low-level, low-level mixed, and TRU wastes are commonly stored in drums at various locations on the Site. In 1996, many drums were vented to prevent pressure buildup from hydrogen gas generated as a product of the reactions associated with radioactive decay of packaged materials. While hydrogen is routinely vented, radionuclide emissions would only occur from these drums if the inner packaging failed. To minimize emissions should the inner packaging fail, the drums were equipped with small filter cartridges that function like HEPA filters. For purposes of estimating emission potential for compliance with 40 CFR 61, Subpart H, and Regulation No. 8, Part A, Subpart H, the packaged materials inside these drums were considered sealed sources (in accordance with Appendix D to 40 CFR 61 and Regulation No. 8, Part A).

In order to reduce waste volumes and to comply with waste storage and shipping requirements, some drums of waste were repackaged in 1996 following waste material separation and consolidation. In addition, some waste forms, including contaminated gloveboxes and duct work, were segregated and size reduced prior to packing for storage and disposal. Such activities exposed the radioactive contamination in the waste to the atmosphere, with resulting emissions.

Radioactive wastes were handled (segregated, size reduced, and repackaged) inside enclosed structures. Emissions from these operations were controlled by venting the air through HEPA filters.

### **Consolidation of Special Nuclear Material (SNM)**

SNM is plutonium and enriched uranium contained in weapons parts, metal and alloy, and oxide. Calendar year 1996 consolidation activities related to SNM encompassed metal brushing, size reduction of metal, thermal stabilization of oxide, and packaging and interim storage of SNM. These consolidation activities are defined as follows:

- **Metal brushing:** Mechanical removal of metal oxide from metal surfaces.
- **Size reduction:** Reduction of material size to accommodate storage containers by breaking, cutting, sawing, and pressing.
- **Thermal stabilization of oxide:** Treatment of unstable forms of metal oxides in furnaces operating in the range of 800 to 1,200 degrees Celsius (°C) to remove moisture and to fully oxidize the metal to stable form.
- **Packaging and storage:** Placement of material in approved, inert atmosphere, storage containers, which in turn are placed in "storage vaults" or "vault-type rooms." Storage vaults are repositories of SNM materials that satisfy defined safety and risk criteria.

Consolidation activities resulted in radionuclide emissions in 1996 through exposure of SNM to ventilation air, as well as through mechanical and thermal disturbance of SNM. Consolidation was performed in areas where ventilation air was exhausted through HEPA filters.

### **Waste Treatment Projects**

Radionuclide emissions were generated in 1996 from waste characterization, research and development activities related to waste processing, and pilot-scale waste treatment projects. Most of the treatable low-level, low-level mixed, and TRU waste materials at the Site were generated during plutonium weapons component production and radionuclide recovery operations conducted prior to 1989.

Laboratory-scale and pilot-scale research and development projects are ongoing at the Site in support of proposed waste treatment plans. Proposed technologies and treatment systems that were evaluated in 1996 included thermal stabilization, cementation, polymer solidification, microwave vitrification, and chemical oxidation processes. In addition, a program to sample and characterize plutonium-containing residues so that decisions can be made regarding the final disposition of the

materials was initiated in 1995 and continued during 1996. The waste treatment-related activities that occurred in 1996 took place in areas where ventilation air was exhausted through HEPA filters.

### **Remediation Projects**

As cleanup of the Site continues, remediation activities also contribute to the resuspension of contaminated soils and debris. In 1996, remediation activities at the Site included excavation and handling of previously buried radioactive waste and debris, excavation and thermal treatment of contaminated soil, heavy equipment traffic, and demolition of contaminated buildings. Emissions from these activities were controlled using dust suppression techniques and HEPA filtration, where feasible.

### **Miscellaneous Non-Point Sources**

Another contributor to Site radionuclide emissions in 1996 was the resuspension of contaminated soils. Contaminated soils were resuspended by wind erosion, vehicle traffic, and other mechanical soil disturbances. Emissions generated by wind erosion were uncontrolled, while radionuclide emissions from vehicle traffic and mechanical disturbances were generally controlled using dust suppression techniques.

In addition to the resuspension of contaminated soils, two other non-point sources contributed to Site radionuclide emissions in 1996. A drum crushing operation created small amounts of radionuclide emissions by disturbing low levels of radiological contamination on the drum surfaces. Venting underground tanks containing sludge and liquid contaminated with low levels of radionuclides during decontamination activities also contributed to Site emissions in calendar year 1996. These activities are described in more detail in Section 2.2.2 of this report.

#### **2.2.2 New Construction and Modifications in Calendar Year 1996**

A total of 16 new or modified activities that contributed to the Site dose began operation during the 1996 calendar year. These activities involved radioactive materials stabilization; deactivation, decontamination, and decommissioning activities; and remediation of contaminated soils.

The maximum annual (controlled) off-Site EDE expected from each new or modified activity was estimated as part of the project evaluation process. In each case, the estimated EDE (shown below) was less than 1% of the 10 mrem (0.1 mSv) standard. Because the Site is in compliance with 40 CFR 61 (CAQCC Regulation No. 8, Part A), Subpart H, based on the annual report submitted for the 1995 calendar year, neither construction approval nor notification of startup was required for these activities.

In addition, several 1996 projects were undertaken in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLA projects are exempt from the administrative requirements of other regulations, including requirements for pre-construction approval or notification.

The 1996 new or modified activities, which have been classified according to whether or not their emissions were continuously monitored, are described below.

### **Unmonitored Activities**

Prior to construction or modification of an activity that is expected to produce radionuclide air emissions, the maximum annual off-Site EDE that would result from project- or process-specific emissions must be estimated to determine the applicability of monitoring and approval requirements. For the activities described below, expected radionuclide emissions were calculated using emission and control factors from Appendix D to 40 CFR 61 and CAQCC Regulation No. 8, Part A, combined with information regarding radionuclide contaminant levels and material forms, radionuclide release mechanisms, and the radionuclide emission controls employed. Emissions were modeled using the Clean Air Act Assessment Package-1988 (CAP88-PC), Version 1.0, and recent Site meteorological data to estimate annual EDEs at the nearest off-Site residence and business locations. The project- or process-specific EDEs used in making regulatory applicability decisions regarding approval requirements are reported below.

Remediation of Trench 2 (T-2): Remediation of T-2 involved the excavation and thermal treatment of 352,000 kilograms (kg) of contaminated soil. Beginning in 1966, T-2 was used to dispose of radionuclide-contaminated sewage sludge and organic chemicals before the trench was backfilled and its use discontinued in 1970. The trench is located within an area where surface soils were contaminated with americium and plutonium. The surficial radionuclide contaminants were deposited by wind transport of contaminated soils from the 903 Pad drum storage area.

Excavation of contaminated soil from T-2 was completed in 1995. During 1996, the contaminated soil was treated using a thermal desorption unit (TDU) to remove volatile organic compounds (VOCs). The TDU heated the contaminated soils to temperatures ranging from approximately 90 to 375°C. Offgases generated from the thermal desorption unit were exhausted through a cyclone dust collector and a 1.0 micrometer ( $\mu\text{m}$ ) glass fiber filter to a cooled condenser. The condenser exhaust was passed through a HEPA filter, and then polished through an activated carbon filter. After removal from the TDU, the treated soils were stored in covered roll-off containers to await final disposal.

The remediation of T-2 was conducted under CERCLA. Therefore, construction approval and startup notification were not required for this project. However, the maximum off-Site EDE expected from this project was estimated prior to startup of the TDU. The maximum annual off-Site (controlled) EDE from this project was estimated to be  $5.7 \times 10^{-5}$  mrem ( $5.7 \times 10^{-7}$  mSv).

Trenches 3 and 4 (T-3/T-4) Remediation: The remediation of T-3/T-4 involved the excavation and thermal treatment of soil and debris contaminated with VOCs and radionuclides. Trench 3 was used for waste disposal operations from late 1964 through early 1966, and Trench 4 was used for similar operations in 1966 and 1967. Records show that both trenches were used to dispose of sanitary sewage sludge and flattened drums contaminated with plutonium, uranium, and VOCs. Both trenches are located within an area where surface soils were contaminated with low levels of americium and plutonium. The surficial radionuclide contaminants were deposited by wind transport of contaminated soils from the 903 Pad drum storage area.

In 1996, approximately 3,603,000 kg of contaminated material were excavated from T-3/T-4. The excavated soil and debris were separated. The debris was decontaminated using high pressure water spray and brushes, and the contaminated soils were processed on Site using a TDU to remove VOCs. During processing, the soils were heated to temperatures ranging from approximately 90 to 375°C. Offgases generated from the thermal desorption unit were exhausted through a cyclone dust collector and a 1.0 µm glass fiber filter to a cooled condenser. The condenser exhaust was passed through a HEPA filter, and then polished through an activated carbon filter. The processed soils from the TDU were then returned to the trenches.

A backhoe was used to excavate the soil. Water spray and dust suppressants were used to control fugitive particulate emissions generated during excavation and material handling activities, and earth moving operations were not conducted during periods of high winds.

The remediation of T-3 and T-4 was conducted under CERCLA. Therefore, construction approval and startup notification were not required for this project. However, radionuclide emissions were estimated prior to project startup based on average contaminant levels measured in soil samples from the trenches and vicinity. The maximum annual (controlled) off-Site EDE estimated for this project was  $9.1 \times 10^{-4}$  mrem ( $9.1 \times 10^{-6}$  mSv). Emissions were revised following project completion and the revised emission estimates were used in modeling Sitewide emissions for this report. Emission estimation and modeling issues for T-3/T-4 activities are discussed in detail in Section 3.3.1 of this report.

Sewage Treatment Plant Phase III Upgrade: Phase III of the Sewage Treatment Plant (STP) upgrade project was initiated in 1996 and involved the installation of two partial in-ground concrete tanks, referred to as influent and effluent storage tanks. This installation required

excavation of soil for the foundation of the storage tanks, backfilling around the tanks, and hauling excess soils to the on-Site landfill. Water spray was used to control dust emissions during excavation, backfilling, and hauling.

During excavation, radiological contamination was found in soils surrounding a vitrified clay waste line that ran through the area where the storage tanks were to be installed. Approximately 3,800 cubic meters (m<sup>3</sup>) of the soil excavated from the STP site were contaminated with low levels of plutonium and americium. This contaminated soil was stockpiled outside of the on-Site landfill in a staging area and covered with a dust suppression agent to reduce fugitive dust.

When radiological contamination was discovered, the off-Site EDE was calculated based on the volume of contaminated soil excavated and handled, the maximum levels of radionuclides measured in the excavated soils, radionuclide emission factors from Appendix D to 40 CFR 61 and CAQCC Regulation No. 8, Part A, and fugitive dust emission factors from EPA-approved reference materials (EPA, 1995). The maximum annual (controlled) off-Site EDE from this project was estimated to be  $8.6 \times 10^{-3}$  mrem ( $8.6 \times 10^{-5}$  mSv).

Drum Crushing: In order to reduce waste volume, a drum crushing operation was conducted adjacent to a building within the Protected Area in 1996. This drum crushing operation processed non-hazardous drums with low levels of radionuclide contamination. Up to 500 drums were processed in calendar year 1996.

Radionuclide emissions were calculated prior to initiation of the drum crushing operation. Based on the maximum throughput of the operation and maximum contamination levels, the maximum annual off-Site EDE from this operation was estimated to be  $4.6 \times 10^{-8}$  mrem ( $4.6 \times 10^{-10}$  mSv) (the drum crushing operation did not employ emission controls).

Underground Tank Decontamination: Three underground concrete tanks, located in the Protected Area, were decontaminated during 1996. The liquid and sludge that remained in the tanks from previous process activities contained low levels of radionuclides. The decontamination process involved rinsing the inside of the tanks with high pressure water, removing the rinsate and any sediment from the tanks, and filling the tanks with foam to stabilize any remaining contamination. During the decontamination activities, the opening on each tank was covered and vented through a single-stage HEPA filter.

Radionuclide emissions were estimated prior to project initiation. The maximum annual (controlled) off-Site EDE from this project was estimated to be  $2.7 \times 10^{-4}$  mrem ( $2.7 \times 10^{-6}$  mSv).

## Monitored Activities

Several activities or projects that were newly constructed or modified in 1996 took place in buildings where ventilation air was continuously monitored for radionuclides. Measured radionuclide emissions from these vents and stacks were used in calculating the 1996 calendar year maximum off-Site EDE due to Sitewide emissions, as described in Section 4.0 of this report. However, a project- or process-specific EDE must be calculated prior to construction or modification to determine the applicability of monitoring and approval requirements. The anticipated radionuclide emissions and resulting maximum off-Site EDE for each such project or process was estimated using the same methods described previously for unmonitored activities. The project- and process-specific EDEs used in making regulatory applicability decisions regarding approval requirements are reported below.

Decontamination and Decommissioning of Building 889: Building 889 was decontaminated, decommissioned, and removed during 1996. Based on characterization studies, Rooms 105, 106, 107, and 108 of Building 889 were found to have radiological contamination. Decontamination activities involved removing the contaminated surface layers of room materials to reduce contamination to acceptable levels, and decommissioning activities involved the demolition of the building structure. Air effluent samplers in Building 889 were left in place during decontamination activities. Thus, any radionuclide emissions from these activities were measured by these continuous monitors. Ventilation air from the areas being decontaminated was filtered through two stages of HEPA filters prior to release. The maximum annual (controlled) off-Site EDE estimated for this project was  $5.8 \times 10^{-9}$  mrem ( $5.8 \times 10^{-11}$  mSv).

Following decontamination, the building was demolished. Because the building was decontaminated prior to demolition, there were no radionuclide emissions resulting from demolition.

Draining of Highly Enriched Uranyl Nitrate Solutions: During 1996, eight tanks in Building 886 that were used to store uranyl nitrate solutions were drained. Uranyl nitrate solutions were previously used in critical mass experiments conducted by the Criticality Mass Laboratory (CML). However, the CML has been inactive since 1987. The tanks contained a total of approximately 569 kg of highly enriched uranium (as uranyl nitrate) in 2,700 liters of dilute nitric acid. The recovered solutions were shipped to the Oak Ridge DOE facility in Tennessee to be used as a feedstock. Effluent from Building 886 was filtered through two stages of HEPA filters.

Radionuclide emissions were conservatively estimated prior to project initiation based on the total enriched uranium loading in Building 886. The maximum annual (controlled) off-Site EDE estimated for this project was  $1.0 \times 10^{-6}$  mrem ( $1.0 \times 10^{-8}$  mSv).

Ash Residue Treatability Study: An ash treatability study was conducted during 1996 to determine the physical and chemical changes that occur to radionuclide-containing ash residues as they are heated to various temperatures. Information gathered from this study will be used in the development of treatment process parameters for full-scale treatment of ash-type residues. The ash treatability study involved heating the residue material in a furnace in Building 707, Module J. Each residue sample was heated to a maximum of approximately 500°C, cooled, and placed in laboratory vials for subsequent analysis. Radionuclide emissions occurred when radionuclide-containing ash was exposed to ventilation air during these studies.

The furnace was contained within a glovebox that exhausted through four stages of HEPA filters. Due to the extremely small amounts of material processed (no more than 8 kg residue), an EDE was not calculated for this process. However, maximum controlled emissions were expected to be well below the 0.1 mrem (0.001 mSv) approval threshold.

Leaded Rubber Glove Washing: Beginning in the late 1960's, a yellow crystalline compound of lead nitrate in a matrix of organic material was observed on leaded rubber gloves used in gloveboxes. Nitric acid had reacted with the inner lead oxide layer of the glove through cracks, abrasions, or diffusion to produce the yellow substance. The gloves were also contaminated with various levels of radionuclides. Glove washing was performed to remove the crystalline substance between the early 1970's and 1987. In 1996, the glove washing operation was resumed in the Building 776 Advanced Size Reduction Facility's Barrel Dump Glovebox.

The glove washing performed in calendar year 1996 generated radionuclide emissions as contamination on the glove surfaces was exposed to ventilation air in the Barrel Dump Glovebox. The gloves were either wiped with a wet cloth or washed with water, then repackaged into 55-gallon drums. The Barrel Dump Glovebox exhausted through four stages of HEPA filters. The maximum annual (controlled) off-Site EDE estimated for this operation was  $7.0 \times 10^{-4}$  mrem ( $7.0 \times 10^{-6}$  mSv).

Ion Exchange Resin Cementation: In 1996, a cementation treatment process for spent ion exchange resin was initiated in Building 774. Prior to 1989, ion exchange resin was used to purify plutonium solutions as part of the aqueous plutonium recovery process. Approximately 268 kg of used resin have remained in storage since 1989. During the ion exchange process, plutonium ions were selectively adsorbed by the resin. Prior to storage, the resin was drained of free liquids and rinsed with a weak nitric acid solution. The spent resin was treated during 1996 to ensure that the stored resin would not become a safety hazard. There was a concern that, over time, a reaction between the nitric acid rinse and the resin material might produce a flammable by-product. The treatment process conducted in 1996 involved incorporating small quantities of the spent resin into cemented aqueous waste. Prior to cementation, the resin was assayed and

repackaged in Module A of Building 707. The actual cementation process was an existing operation in Building 774 that was modified to incorporate a small batch (up to 1% by weight) of resin into each drum of dry cement and liquid waste. Radionuclide emissions were generated during repackaging of resin prior to transfer to the cementation process and during incorporation of the resin into the cementation process as the radionuclide-contaminated resin was exposed to ventilation air. Air effluent streams from Module A, Building 707, and from Building 774 were both exhausted through four stages of HEPA filters. The maximum annual (controlled) off-Site EDE estimated for the cementation process was  $2.3 \times 10^{-4}$  mrem ( $2.3 \times 10^{-6}$  mSv).

Plutonium Particle Study: In 1996, a project to sample contaminated waste drums for plutonium particles and to analyze the size distribution of the particles was conducted in the Building 776 Advanced Size Reduction Facility's Barrel Dump Glovebox. The purpose of this study was to determine the size distribution of plutonium oxide powder contamination on combustible wastes. Radionuclides were emitted when sampling and analysis exposed the plutonium contamination to ventilation air. Process effluent from this activity was filtered through four stages of HEPA filters. The maximum annual (controlled) off-Site EDE estimated for the plutonium particle study was  $6.1 \times 10^{-7}$  mrem ( $6.1 \times 10^{-9}$  mSv).

Strip-out and Demolition of Modules A, D, E, and J in Building 707: Strip-out and demolition of Modules A, D, E, and J in Building 707 were conducted during 1996. The strip-out and demolition activities involved the removal of gloveboxes (in Modules A and J); the removal of associated glovebox equipment (in Modules A, D, E, and J); and the removal of office furniture, cabinets, tables, X-ray machines, and other loose items (in Module A). Size reduction of equipment and gloveboxes was performed using a Sawz All™.

Prior to the removal and demolition of gloveboxes and equipment (in Modules A, D, E, and J), a stripcoat decontamination material was applied to the glovebox and equipment surfaces to reduce the contamination levels. The stripcoat decontamination material controlled 90% of the potential emissions of removable contamination and material hold-up on the interior surfaces of the gloveboxes.

Tents were also constructed around the gloveboxes in Modules A and J to control the release of contaminants. The effluent streams generated during the strip-out and demolition activities in Modules A and J were exhausted through single-stage portable HEPA filters from the contamination control tents to the room air. In turn, the room air was exhausted through two stages of HEPA filters. Effluent streams from Modules D and E were exhausted through four stages of HEPA filters.

The strip-out and demolition of each module was conducted as a separate project and radionuclide emissions were calculated for each activity based on contamination levels in or on the equipment affected. The following maximum annual (controlled) off-Site EDEs were estimated for the strip-out and demolition activities: Module A,  $1.2 \times 10^{-7}$  mrem ( $1.2 \times 10^{-9}$  mSv); Module D,  $3.9 \times 10^{-6}$  mrem ( $3.9 \times 10^{-8}$  mSv); Module E,  $2.7 \times 10^{-6}$  mrem ( $2.7 \times 10^{-8}$  mSv); and Module J,  $2.3 \times 10^{-6}$  mrem ( $2.3 \times 10^{-8}$  mSv).

Strip-out and Demolition of Room 3206 in Building 371: Strip-out and demolition of Room 3206 in Building 371 was conducted in 1996. The strip-out and demolition activities involved the removal of three gloveboxes along with associated equipment, piping, and loose items within the gloveboxes; removal of vacuum lines, a pump, electrical wiring, and piping within Room 3206; and modification of three other gloveboxes that were left in place. Size reduction of equipment and gloveboxes was performed using a Sawz All™.

Prior to the removal and demolition of the gloveboxes in Room 3206, a stripcoat decontamination material was applied to the glovebox surfaces to reduce the contamination levels. The stripcoat decontamination material controlled 90% of the potential emissions of removable contamination and material hold-up on the interior surfaces of the gloveboxes. A tent was also constructed around the gloveboxes to control the release of contaminants. The effluent generated during the strip-out and demolition activities was exhausted through a two-stage portable HEPA filter from the contamination control tent to the room air. In turn, the room air was exhausted through two stages of HEPA filters.

Radionuclide emissions from the strip-out and demolition of Room 3206 could not be quantified prior to project initiation because material hold-up data were not available for the gloveboxes and equipment in Building 371. However, based on process data, a 90% control efficiency for the stripcoat material, and the radionuclide emission estimates that were performed for the strip-out and demolition activities in Building 707, the maximum annual (controlled) off-Site EDE was judged to be several orders of magnitude below the 0.1 mrem approval threshold.

## 3.0 AIR EMISSIONS DATA

This section discusses and quantifies radionuclide emissions from the Site for calendar year 1996. The stacks, vents, and other points where radioactive materials were released to the atmosphere are described and the effluent controls employed by the Site to minimize emissions are discussed.

### 3.1 Emission Determination Process

The emission data presented in this section represent the radionuclide emissions used in determining Site compliance with the annual 10 mrem (0.1 mSv) public dose standard for calendar year 1996. In some cases, air effluent exiting buildings through stacks or vents was continuously monitored for radionuclide emissions in 1996. Where such data were available, the measured emissions were used in compliance modeling (discussed in Section 4.0 of this report). In other cases, activities that generated radionuclide emissions were not monitored. For these activities, emissions were estimated based on project- or process-specific information, combined with emission factors from various sources.

As described in Section 2.2.2, expected radionuclide emissions must be evaluated for proposed new or modified sources of radionuclide air emissions to determine compliance requirements and to evaluate the need for additional controls. For projects or processes that were not subsequently monitored, this initial emission estimate was generally also used for the annual Sitewide compliance demonstration modeling. However, where actual conditions differed from the assumptions on which the initial estimate was based, emissions were re-estimated after the project was complete or the process had begun operation. For calendar year 1996, radionuclide emissions from the T-3/T-4 remediation project were revised from the initial estimate and the revised emissions subsequently used in the compliance demonstration described in Section 4.0 of this report.

Where emissions reported in this section were estimated, rather than directly measured, the emission estimates were based on:

- The radionuclide content of materials handled or processed;
- The form of the radioactive material (gas, liquid, solid, or particulate);
- The mechanisms by which radionuclides were released to the atmosphere;

- The time over which the activities that released radionuclides occurred or the time that the radioactive material was exposed to the atmosphere;
- The control measures employed to reduce radionuclide emissions; and
- Process- or activity-specific emission factors.

Emission factors were derived from several sources. Radionuclide emission factors listed in Appendix D to 40 CFR 61 and CAQCC Regulation No. 8, Part A were used to calculate emissions due to exposure of radioactive material to the atmosphere during processing or handling. Additional emissions resulting from the release of radionuclide-contaminated particles through handling or processing soil and debris were based on emission factors in EPA's "Compilation of Air Pollutant Emission Factors" (EPA, 1995). Finally, a post-project analysis of emissions from the T-3/T-4 remediation project (discussed in detail in Section 3.3.1 of this report) used emission data from a DOE publication, "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities" (DOE, 1994). The appropriate emission factors were combined with project- or process-specific information to yield estimated radionuclide emissions.

In addition to the emission estimates calculated for specific projects or processes, an ongoing source of radionuclide emissions from the Site is the resuspension of contaminated surface soils by wind erosion. Emissions from this source were estimated by combining information regarding Site-wide surface soil concentrations of radionuclide contaminants with a Site-specific soil resuspension factor.

Historical surface soil radionuclide concentration data from a Site-specific soil sampling database (Rocky Flats Environmental Data Base System [RFEDS]) were used to develop a set of radionuclide concentration isopleths spanning the entire Site. No new soil samples were added to the database in 1995; therefore, the soil resuspension emissions for 1996 were the same as those reported in the 1995 calendar year report. The development of the Site-specific soil resuspension rate used in emission calculations was discussed in detail in a previous annual report (DOE, 1996).

### **3.2 Point Sources**

Radionuclide emissions released through stacks and vents are termed "point" sources. In calendar year 1996, radionuclide point sources at the Site included releases from buildings in the industrial area, as well as emissions from thermal treatment of contaminated soils from T-2, T-3, and T-4; emissions from decontamination of underground tanks; and radionuclides released from waste segregation operations in Cargo Container C-549-1.

Point source emissions for calendar year 1996 and the control technology used on each point source are described in this section.

### **3.2.1 Monitored Point Source Emissions**

Regulation 40 CFR 61.93 (CAQCC Regulation No. 8, Part A, Section 61.93) requires that radionuclide emissions be continuously monitored at all release points that have the potential to discharge radionuclides into the air in quantities that would result in an annual EDE to the public greater than 1% of the standard, based on uncontrolled emissions (without considering HEPA filtration). There were 23 such significant point sources at the Site in 1996. Monitored emissions of plutonium, uranium, and americium from these significant emission points for calendar year 1996 are shown in Table 3-1.

For release points that have the potential to discharge radionuclides in lesser quantities, 40 CFR 61.93 (CAQCC Regulation No. 8, Part A, Section 61.93) requires periodic confirmatory measurements to verify the low emissions. In calendar year 1996, there were 40 ducts or vents exiting process buildings (constituting 30 emission points) with potential annual EDEs less than 1% of the standard. Continuous emission monitoring continued at these "insignificant" point source locations in calendar year 1996. In July 1996, monitoring of the insignificant point source located in Building 889 was discontinued when the building was demolished and removed, reducing the number of insignificant point sources to 39. Monitored emissions of plutonium, uranium, and americium from insignificant emission points for calendar year 1996 are also shown in Table 3-1.

The air effluent monitors employed to measure plutonium, uranium, and americium emissions from process buildings continuously sampled the exhaust stream and collected particles on filters. The sample filters were collected from each significant point source monitor weekly and from each insignificant point source monitor monthly in 1996. The samples were screened for long-lived alpha and beta radiation following collection to provide a quick check for elevated radionuclide emissions.

Following alpha/beta screening, the samples were composited by location and analyzed for plutonium, uranium, and americium isotopes. All radionuclides that could contribute greater than 10% of the potential EDE for a release point were measured. Monthly composites were analyzed for each significant point source location. An annual composite was analyzed for each insignificant point source location.

Six emission points were also sampled for tritium through October 1996, as indicated in Table 3-1. Tritium sampling was discontinued at location 707-102 on October 3, leaving only five

Table 3-1

## Monitored Point Source Radionuclide Emissions for Calendar Year 1996

Building/ Location*	Isotope Emissions (Ci/yr) <sup>b,c,d</sup>					
	Pu-238	Pu-239/240	Am-241	U-233/234	U-238	H-3
<b>Significant Sources</b>						
371-N01	1.56 E-10	2.18 E-09	1.01 E-09	1.09 E-08	9.83 E-09	
371-N02	1.88 E-09	1.98 E-09	1.15 E-09	6.96 E-09	6.69 E-09	--
371-SSS	6.56 E-11	1.26 E-09	8.27 E-10	8.90 E-09	9.55 E-09	--
374-MAI	8.41 E-10	4.26 E-09	1.15 E-09	7.01 E-09	5.53 E-09	--
559-561	- 5.03 E-11	1.74 E-08	1.04 E-08	3.68 E-08	4.46 E-08	--
707-101	6.23 E-11	1.77 E-10	6.73 E-11	- 3.90 E-10	- 3.96 E-10	--
707-102	9.61 E-11	1.08 E-10	2.64 E-11	- 1.04 E-09	- 1.25 E-09	7.72 E-02
707-105	1.22 E-10	5.33 E-10	1.82 E-10	3.01 E-09	2.36 E-09	--
707-106	9.83 E-11	1.53 E-10	1.55 E-10	- 3.33 E-10	- 7.74 E-10	--
707-107	3.07 E-10	9.81 E-10	7.96 E-10	6.80 E-09	5.10 E-09	--
707-108	- 1.41 E-11	5.86 E-10	2.83 E-10	3.66 E-09	3.46 E-09	--
707-R45A/B	6.18 E-10	2.58 E-09	2.12 E-09	- 2.20 E-09	- 3.25 E-09	--
771-MAI	3.34 E-08	6.62 E-07	1.22 E-07	- 8.35 E-09	1.75 E-08	--
774-202	- 1.04 E-11	6.66 E-10	9.43 E-10	- 1.32 E-09	- 1.01 E-09	--
776-201	1.78 E-11	5.50 E-11	2.68 E-11	- 9.63 E-11	- 9.32 E-11	--
776-202	3.53 E-10	1.89 E-09	4.78 E-10	- 4.56 E-12	- 6.21 E-10	--
776-204	1.25 E-10	2.37 E-09	7.99 E-10	6.79 E-09	6.69 E-09	--
776-205	1.43 E-10	1.12 E-09	3.58 E-10	- 1.15 E-09	- 1.50 E-09	4.12 E-01
776-206	4.99 E-10	4.33 E-09	3.74 E-10	- 3.13 E-10	- 1.14 E-09	1.30 E+00
776-207	2.66 E-10	3.18 E-10	2.90 E-10	- 4.09 E-09	- 4.41 E-09	--
776-250	3.70 E-09	6.85 E-08	1.08 E-07	- 3.57 E-08	- 1.64 E-07	1.56 E+00
779-729	7.31 E-10	7.87 E-10	1.19 E-10	- 3.59 E-09	- 3.06 E-09	--
779-782	3.80 E-10	5.99 E-09	2.47 E-09	2.48 E-08	2.64 E-08	1.98 E+00
<b>Insignificant Sources</b>						
374-SPD	7.21 E-11	3.49 E-09	2.14 E-09	- 1.66 E-09	1.06 E-10	--
444-DO5	--	--	--	4.35 E-09	3.95 E-09	--
444-MAI	--	--	--	- 7.48 E-08	- 5.62 E-08	--
447-MAI	--	--	--	- 2.51 E-09	3.55 E-10	--
707-R21A/B	6.47 E-13	2.19 E-09	5.31 E-09	- 1.38 E-08	- 1.00 E-08	--
707-R22A/B	- 4.57 E-10	7.86 E-10	4.57 E-09	- 1.25 E-08	- 1.18 E-08	--
707-R23A/B	- 5.80 E-11	1.07 E-09	4.15 E-09	- 1.04 E-08	- 1.45 E-08	--
707-R24A/B	- 1.66 E-10	1.84 E-09	4.56 E-09	- 1.35 E-08	- 1.08 E-08	--
707-R25A/B	- 4.01 E-10	4.80 E-10	4.96 E-09	- 3.11 E-09	- 7.70 E-09	--
707-R26A/B	- 4.37 E-10	1.71 E-09	4.53 E-09	- 1.45 E-08	- 1.92 E-08	--
707-R27A/B	- 1.95 E-10	3.58 E-09	4.51 E-09	- 1.03 E-08	- 8.03 E-09	--

Table 3-1

**Monitored Point Source Radionuclide Emissions for Calendar Year 1996  
(Continued)**

Building/ Location	Isotope Emissions (Ci/yr) <sup>a,c,d</sup>					
	Pu-238	Pu-239/240	Am-241	U-233/234	U-238	H-3
<b>Insignificant Sources</b>						
707-R46A/B	- 3.55 E-10	1.38 E-09	1.11 E-08	- 2.52 E-09	- 3.79 E-09	--
771-CMA	- 4.08 E-13	2.29 E-09	2.97 E-09	8.14 E-10	1.13 E-08	--
771-CRM8/10	- 1.60 E-10	2.40 E-09	4.31 E-09	- 1.16 E-10	9.36 E-09	--
776-251	- 9.98 E-11	- 1.27 E-10	- 1.05 E-09	- 4.76 E-08	- 4.72 E-08	8.80 E-01
776-252	- 5.10 E-11	9.79 E-11	1.36 E-09	- 1.07 E-09	- 1.70 E-09	--
778-LDY	2.69 E-09	1.22 E-07	9.46 E-09	1.11 E-07	7.15 E-07	--
865-EEE	--	--	--	- 1.22 E-08	- 1.20 E-08	--
865-WWW	--	--	--	- 2.30 E-08	8.96 E-09	--
881-MA1	- 2.41 E-09	2.58 E-08	- 1.98 E-09	- 5.10 E-08	- 6.42 E-08	--
881-MA2	- 9.46 E-10	1.41 E-08	6.66 E-09	- 3.95 E-08	- 4.61 E-09	--
881-MA3	- 1.81 E-09	6.32 E-08	2.45 E-09	- 7.63 E-08	- 3.94 E-08	--
881-MA4	- 5.42 E-10	2.76 E-08	2.59 E-09	2.56 E-07	9.17 E-07	--
883-AAA	--	--	--	- 1.73 E-08	- 2.08 E-08	--
883-BBB	--	--	--	- 9.56 E-09	- 1.08 E-08	--
883-CCC	--	--	--	9.50 E-09	1.37 E-08	--
886-875	8.69 E-10	9.14 E-10	3.56 E-10	- 3.01 E-09	- 4.39 E-09	--
889-MAI <sup>d</sup>	- 5.82 E-12	4.36 E-10	2.65 E-10	8.84 E-09	9.58 E-09	--
991-985	4.43 E-11	7.00 E-10	- 1.48 E-10	- 2.22 E-08	- 2.18 E-08	--
991-MAI	- 9.85 E-12	6.30 E-10	- 9.63 E-10	- 8.16 E-09	- 5.80 E-09	--

<sup>a</sup> The first number in this column designates the building, the second set of characters designates the specific duct(s) or vent(s). The location of each emission point is shown in Figure 4-2 of this report.

<sup>b</sup> Values were corrected for filter blanks. Negative values resulted when observed measurements were less than average filter blank values. Sources showing negative values were modeled with an emission rate of 0 Ci/yr.

<sup>c</sup> All monitored point sources were controlled by HEPA filters with a tested control efficiency of at least 99.97%.

<sup>d</sup> All isotopes that could contribute greater than 10% of the potential EDE for a release point were measured. Isotopes not analyzed are shown as "--".

<sup>e</sup> Building 889 was demolished and sampling was discontinued in July 1996.

## Notes:

Ci/yr	=	Curies per year; 1 Ci = 3.7 x 10 <sup>10</sup> Becquerel (Bq)
Pu	=	Plutonium
Am	=	Americium
H-3	=	Tritium
U	=	Uranium
E#	=	x 10 <sup>e</sup>
--	=	Not analyzed

points for tritium sampling during the remainder of 1996. Tritium samples were analyzed as they were collected, two to three times a week.

Appendix B shows 1996 monitored point source emissions data contained in DOE's Effluent Information System (EIS). DOE did not publish an EIS report for 1996.

### **3.2.2 Unmonitored Point Sources**

In calendar year 1996, several unmonitored point sources also operated at the Site. These sources included the TDUs used to treat contaminated soil from T-2 and from T-3/T-4, an underground tank decontamination project, a waste segregation operation in Cargo Container C-549-1, and laboratory operations that emitted tritium. The thermal treatment of T-2 and T-3/T-4 soils and the underground tank decontamination project are described in Section 2.2.2 of this report. The waste segregation operation in Cargo Container C-549-1 began operations in 1965 and was described in a previous annual report (DOE, 1996). Buildings 123, 881, and 790 had low-level tritium emissions for which monitoring is not performed.

Emissions for unmonitored point sources that operated at the Site in calendar year 1996 were estimated as described in Section 3.1. Table 3-2 shows unmonitored point source emission estimates for calendar year 1996.

### **3.2.3 Control Technology for Point Sources**

HEPA filters are used to control radioactive particulate emissions from air effluent systems. All of the monitored point source locations listed in Table 3-1 used HEPA filtration in 1996. Air effluent from plutonium processing areas was cleaned by a minimum of four stages of HEPA filters. Air effluent from areas that processed plutonium-contaminated waste was typically cleaned by two stages of HEPA filters. Air effluent from uranium processing areas was generally cleaned by a minimum of two stages of HEPA filters.

HEPA filters are bench tested prior to installation in the buildings to ensure that they would meet a minimum filter efficiency of 99.97%. Filter assemblies are tested again for leaks following installation.

Emissions from the waste segregation area in Cargo Container C-549-1, the TDUs that were used to treat soil from T-2 and T-3/T-4, and the underground tank decontamination project were also controlled using single-stage HEPA filtration. The tritium emissions shown in Tables 3-1 and 3-2 were uncontrolled (HEPA filters do not control tritium, which is released as a gas).

Table 3-2

Unmonitored Point Source Radionuclide Emissions for Calendar Year 1996

Activity or Building	Isotope Emissions (Ci/yr) <sup>a</sup>					
	Pu-239/ 240	Am-241	U-233/234	U-235	U-238	H-3
Underground Tank Decontamination <sup>b</sup>	1.01 E-07	3.58 E-08	1.45 E-12	5.57 E-13	7.09 E-13	1.20 E-09
Waste Segregation (C-549-1) <sup>b</sup>	1.00 E-08	1.00 E-08	--	1.00 E-08	1.00 E-08	--
T-2 Thermal Treatment <sup>b</sup>	8.72 E-05	3.97 E-05	6.01 E-05	2.50 E-06	6.58 E-05	--
T-3/T-4 Thermal Treatment <sup>b</sup>	3.89 E-05	2.17 E-05	2.97 E-04	1.96 E-05	5.07 E-04	--
123 <sup>c</sup>	--	--	--	--	--	2.11 E-07
881-MAI <sup>c</sup>	--	--	--	--	--	9.19 E-06
790 <sup>c</sup>	--	--	--	--	--	1.18 E-05

<sup>a</sup> Emissions of all isotopes that could contribute greater than 10% of the potential EDE for a release point were estimated. Isotopes for which emissions were not estimated are shown as "--". The locations of the unmonitored point sources listed are shown in Figures 4-2 through 4-8 of this report.

<sup>b</sup> HEPA filtration used with a control efficiency of at least 99.97%.

<sup>c</sup> Uncontrolled for tritium.

Notes:

- Ci/yr = Curies per year; 1 Ci=3.7 x 10<sup>10</sup> Becquerel (Bq)
- Pu = Plutonium
- Am = Americium
- U = Uranium
- H-3 = Tritium
- = Not estimated
- E# = x10<sup>#</sup>

### **3.3 Non-Point Sources**

Radionuclide emissions that are not released through specific stacks or vents are termed "non-point" (or diffuse) sources. In calendar year 1996, non-point sources of radionuclide emissions at the Site included resuspension of contaminated soils by wind erosion and by mechanical disturbance due to excavation, handling, and vehicle traffic. In 1996, mechanical disturbance of contaminated soils was associated with the Sewage Treatment Plant Phase III Upgrade and with the remediation of T-3/T-4. The T-3/T-4 project also released radionuclides to the atmosphere through the excavation and handling of radioactive material and debris. Finally, calendar year 1996 non-point sources also included the drum crushing operation inside the Protected Area. The projects and operations that generated non-point air emissions of radionuclides in 1996 are described in Sections 2.2.1 and 2.2.2 of this report.

Calendar year 1996 emissions from non-point sources and the methods used to minimize emissions are described below. Table 3-3 summarizes emissions from non-point sources for calendar year 1996.

The emissions shown in Table 3-3 include the uranium isotopes typical of the depleted and enriched uranium that has been used at the Site, as well as other isotopes that are present in Site soils. Pu-239/240 constitutes more than 97% of the alpha activity in plutonium used at the Site. Consequently, emissions for selected plutonium isotopes (Pu-238, -241, and -242) were not included in the 1996 dose calculation because each has the potential to contribute much less than 10% of the total EDE.

#### **3.3.1 Trench 3 and Trench 4 Remediation**

The remediation of T-3 and T-4 contributed over 90% of the total Sitewide dose to the public in calendar year 1996 (see additional discussion in Section 4.0 of this report).

Non-point emissions were generated from excavation and soil handling activities associated with the remediation of these trenches and from exposure of radionuclides to the atmosphere. The radionuclide emissions from the non-point source component of the T-3/T-4 remediation are shown in Table 3-3. Point source emissions from the TDU used to treat contaminated soils from the T-3/T-4 remediation are discussed in Section 3.2.2 and are shown in Table 3-2. The methods used to calculate the T-3/T-4 emissions are discussed below.

Screening analysis emissions were calculated for the T-3/T-4 excavation and soil handling activities prior to project startup using the average radionuclide contamination levels in soil samples taken in the area to be excavated, combined with EPA emission factors for fugitive dust

Table 3-3

## Non-Point Source Radionuclide Emissions for Calendar Year 1996

Isopleth or Project <sup>a</sup>	Isotope Emissions (Ci/yr) <sup>b</sup>				
	Pu-239/240	Am-241	U-233/234	U-235	U-238
Isopleth 1	8.26 E-07	3.17 E-07	6.49 E-09	2.32 E-08	1.00 E-10
Isopleth 2	3.55 E-08	5.55 E-09	4.90 E-08	2.00 E-09	2.21 E-09
Isopleth 3	8.61 E-07	4.24 E-07	4.84 E-09	2.37 E-08	1.57 E-08
Isopleth 4	4.10 E-08	1.57 E-08	3.09 E-08	9.79 E-10	1.37 E-08
Isopleth 5	2.33 E-06	8.21 E-10	5.76 E-08	2.01 E-08	5.02 E-09
Isopleth 6	9.53 E-08	8.06 E-09	6.58 E-09	--	5.92 E-10
Isopleth 7	1.62 E-07	1.20 E-06	3.37 E-08	--	2.88 E-09
Isopleth 8	3.31 E-06	6.00 E-08	7.25 E-08	--	--
Isopleth 9	3.43 E-08	8.44 E-09	6.27 E-09	--	--
Isopleth 10	3.25 E-06	1.02 E-08	9.58 E-08	--	--
Isopleth 11	3.89 E-07	4.18 E-07	8.33 E-08	--	--
Isopleth 12	4.18 E-08	5.11 E-08	3.80 E-09	--	--
Isopleth 13	5.13 E-07	5.59 E-07	8.80 E-08	--	--
Isopleth 14	1.99 E-06	1.00 E-07	--	--	--
Isopleth 15	1.94 E-07	6.03 E-07	--	--	--
Isopleth 16	2.76 E-06	6.86 E-07	--	--	--
Isopleth 17	5.12 E-06	8.81 E-07	--	--	--
Isopleth 18	5.17 E-06	5.44 E-07	--	--	--
Isopleth 19	5.17 E-06	--	--	--	--
Isopleth 20	3.26 E-06	--	--	--	--
T-3/T-4 Excavation and Backfill <sup>c</sup>	1.17 E-04	6.50 E-05	8.92 E-04	5.89 E-05	1.52 E-03
Sewage Treatment Plant Phase III Upgrade <sup>c</sup>	2.72 E-05	1.10 E-04	7.21 E-06	3.00 E-07	5.51 E-06
Drum Crushing <sup>d</sup>	4.60 E-08	--	--	--	--

<sup>a</sup> Isopleths are specific to each isotope and indicate zones of equal radionuclide emission potential for contaminated surface soils.

<sup>b</sup> Emissions of all isotopes that could contribute greater than 10% of the potential EDE for a release point were estimated. Isotopes for which emissions were not estimated are shown as "--". The locations of the non-point emission sources listed are shown in Figures 4-2 through 4-8 of this report.

<sup>c</sup> Water spray/dust suppression used with a control efficiency of 50%.

<sup>d</sup> Uncontrolled.

## Notes:

Ci/yr	=	Curies per year; 1 Ci = $3.7 \times 10^{10}$ Becquerel (Bq)
Pu	=	Plutonium
Am	=	Americium
U	=	Uranium
H-3	=	Tritium
--	=	Not estimated
E#	=	$\times 10^{\#}$

from excavation and soil handling activities (EPA, 1995). Emissions due to exposure of radionuclides to the atmosphere and due to treatment of contaminated soil in a TDU were calculated using emission factors from 40 CFR 61 (CAQCC Regulation No. 8, Part A), Appendix D, combined with average radionuclide contamination levels in the project soils.

Monitored radionuclide concentrations at the Site boundary and from on-Site locations from the period during which excavation, soil handling, and treatment took place indicated that emissions from these activities were higher than originally estimated in the screening analysis. Elevated concentrations of uranium isotopes were observed in monthly monitoring data from July, August, and September 1996.

Emissions from the project were recalculated after project completion using the maximum contamination data, combined with project-specific operations data and air release fractions developed by DOE for radionuclide emissions from handling, resuspension, and heating of contaminated soils (DOE, 1994). The revised emissions were modeled using CAP88-PC for receptors representing the locations of on-Site and off-Site monitors, as well as for nearby public receptor locations. Weekly particulate monitoring performed by CDPHE near the T-3/T-4 project indicated that elevated particulate (and associated radionuclide) emissions occurred primarily during two weeks out of the three-month period. Consequently, meteorological data from the on-Site meteorological tower for those two weeks only were used in the modeling exercise.

Comparison of modeled and monitored radionuclide concentrations at the monitor locations showed that the revised emission estimates more closely matched monitored levels of radionuclides (see Section 5.0 of this report). Consequently, the revised emission estimates for the T-3/T-4 project are shown in Table 3-3 and were used in calculating total Site EDE for 1996.

### **3.3.2 Other Non-Point Sources**

As described in Section 3.1, an ongoing source of radionuclide emissions from the Site is the resuspension of contaminated soil. Calendar year 1996 emissions from wind erosion of contaminated soil are summarized in Table 3-3 and are labeled as isopleths. Each isopleth encompasses an area of equal soil resuspension emission potential for a given isotope.

In addition to emissions from resuspension of contaminated soil by wind erosion and the T-3/T-4 project described previously, two other projects generated non-point radionuclide emissions in 1996. As described in Section 2.2.2, Phase III of the Sewage Treatment Plant upgrade project generated radionuclide emissions when a radiologically contaminated waste line and associated contaminated soils were excavated and removed from the area where new tanks were installed. In addition, minor amounts of non-point radionuclide emissions were released from a drum crushing

operation that was conducted external to buildings in the Protected Area. Emissions from these projects are also shown in Table 3-3.

### **3.3.3 Control Technology for Non-Point Sources**

Particulate emissions from earth moving activities at the Site, such as those involved in the remediation of T-3/T-4 and the Sewage Treatment Plant Phase III Upgrade, were controlled by water spray or other dust suppression measures with an estimated control efficiency of 50%. Fugitive dust control plans that specified the control measures to be used to minimize emissions of contaminated dust were developed for each project with the potential to generate radionuclide emissions from soil or debris handling.

## 4.0 DOSE ASSESSMENT

This section describes the dose assessment performed for the Site for the 1996 calendar year.

### 4.1 Description of Dose Model

The Site used the dose model CAP88-PC (Version 1.0) for calculating EDE to the public. The model simulates the dispersion of radionuclide emissions from point and non-point (termed "area") sources to user-specified receptor locations, then calculates an annual, multi-pathway EDE for a person living or working at each specified receptor location.

The model accounts for dose received through inhalation and ingestion of radionuclides, as well as through irradiation from radionuclides in air and deposited on the ground surface. To simulate pollutant dispersion and calculate dose, the model requires the following types of input data:

- Distance and direction from emission sources to receptor locations.
- Source release characteristics including stack locations, stack heights, exhaust gas velocities and temperatures, the size of each stack or vent opening, and the size and location of each area source.
- The amount of each radioactive isotope released from each source.
- Meteorological data including the annual distribution of wind speed, wind direction, and atmospheric stability at the Site, and annual precipitation and temperature information. The model also requires information about the average height of regional temperature inversions (mixing height).
- Agricultural data used in calculating radionuclide ingestion rates including the location, distribution, and utilization of local sources of meat, milk, and vegetables.
- Miscellaneous data regarding the size and solubility of particles emitted.

The input data used in calculating the 1996 calendar year Site dose to the public are discussed in Section 4.2.

## **4.2 Summary of Model Input Data**

This section describes the dose model input data used to calculate EDE to the public for the 1996 calendar year.

### **4.2.1 Receptors**

Compliance with the 10 mrem (0.1 mSv) public dose standard of 40 CFR 61.92 (CAQCC Regulation, No. 8, Part A, Section 61.92) is determined by calculating the highest EDE to any member of the public at any off-Site point where there is a residence, school, business, or office. Modeling was performed for seven receptor locations, shown on Figure 4-1. These locations represent the residences, businesses, schools, and office buildings nearest the Site. Modeling determined that the maximally exposed individual (MEI) for 1996 was located at a distance of 4,425 m to the northeast of the central, industrial portion of the Site. The model input data described in the rest of Section 4.2 are those values used in calculating the MEI dose for 1996.

### **4.2.2 Point Source Input Data**

Based on previous Site dose assessments, it was expected that routine emissions from point sources at the Site would contribute a small amount to the total 1996 dose. Therefore, to streamline the modeling analysis, most 1996 point source emissions were conservatively combined and modeled from a single location within the central area of the Site. In addition, the radionuclide emissions from one non-point source, the drum crushing operation described in Section 2.2.2, were also included in the combined point source due to the very small emissions generated by the drum crushing operation and its close proximity to the point sources that were combined for the modeling analysis. Only the T-2 and T-3/T-4 TDUs were modeled as separate point sources.

The combined point source emissions were modeled at an average release height using a conservative stack diameter (based on actual stack data) and an exit velocity characteristic of obstructed flow (such as would occur at a release point with a non-vertical stack or rain cap). Several sets of stack parameters were screened to determine which set would result in the highest point source EDE to the public. The T-2 and T-3/T-4 TDUs were modeled separately, using stack data specific to the units.

Figure 4-2 shows the location of individual emission sources that were combined for modeling purposes, as well as the location from which the combined emissions were modeled. Figure 4-3 shows the location of projects whose point-source emissions were not combined for the dose modeling: the T-2 TDU and the T-3/T-4 TDU. Table 4-1 shows the release characteristics for the



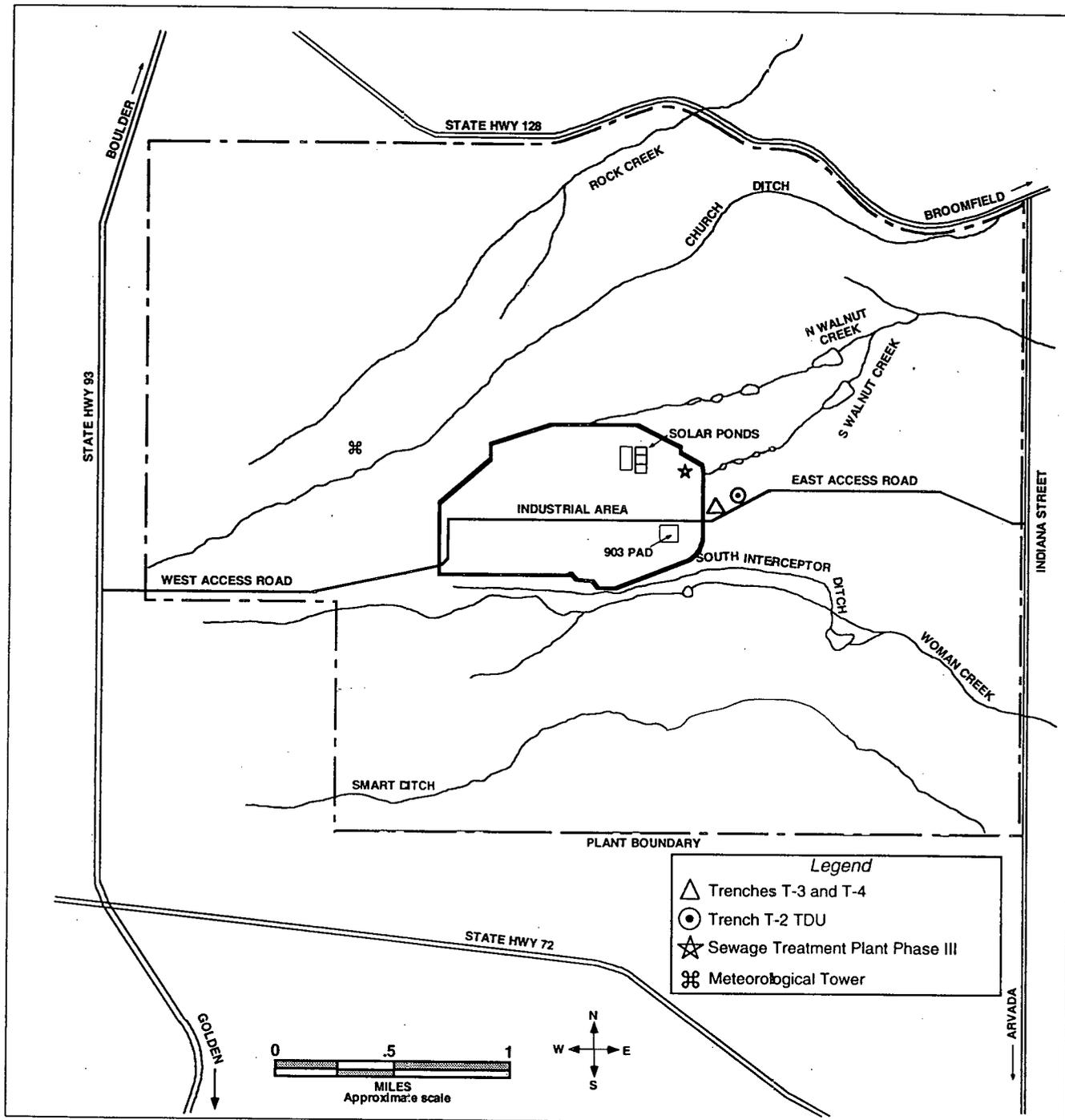


Figure 4-3. Project Emission and Meteorological Data Collection Locations

Table 4-1

Source Data for Model Input--Point Sources

Parameter	Combined Point Source Values	T-2 TDU Values	T-3/T-4 TDU Values
Height (m)	9.1	3.66	3.66
Diameter (m)	0.4	0.61	0.61
Exit Velocity (m/s)	0.1	3.23	3.23
Distance to MEI (m)	4,425	3,600	3,772
Direction to MEI	NE	NNE	NE

Notes:

- m = Meters
- m/s = Meters per second
- MEI = Maximally exposed individual
- TDU = Thermal desorption unit

combined emissions source, the T-2 TDU, and the T-3/T-4 TDU. Detailed information regarding the characteristics of individual release points is given in Appendix C.

#### **4.2.3 Non-Point Source Input Data**

As described in Section 3.1, emissions from wind resuspension of contaminated soil were estimated based on surface soil radionuclide concentration isopleths for the Site that have been developed based on a Site-specific soil sampling database, combined with geographic information system (GIS) software. The GIS was used to compute the area of each isopleth, the centroid of each isopleth (representing the center of mass of the radionuclide contamination), and the distances from each centroid to each receptor. The area of each isopleth and the distance and direction to the MEI receptor are shown in Tables 4-2 through 4-6 for each of the isotopes modeled.

CAP88-PC simulates each non-point source as a point source at the centroid of the source area. The location of the individual non-point (area) sources that were modeled representing the T-3/T-4 excavation and backfill emissions and the Sewage Treatment Plant Phase III Upgrade emissions are shown in Figure 4-3 (source input data for these sources are listed in Table 4-7). The soil resuspension isopleth centroid locations are shown in Figures 4-4 through 4-8. Non-point source emissions were simulated as groundlevel releases (height = 0.0 m) with no momentum plume rise (exit velocity = 0.0 meters per second [m/s]).

#### **4.2.4 Meteorological Data**

Meteorological data for calendar year 1996 were collected from a tower located in the western portion of the Site (the tower location is shown in Figure 4-3). A joint frequency distribution of wind speed, wind direction, and stability was processed for input to CAP88-PC using a commercially available software program (BEEMET). A "wind rose" graphical representation of the meteorological data is shown in Figure 4-9. Appendix D gives a detailed listing of the joint frequency meteorological data for calendar year 1996.

An examination of project schedules and emission estimates showed three projects that could contribute substantially to the Site EDE for 1996 whose emissions were released over relatively short time periods. These were the T-3/T-4 project, the T-2 thermal treatment operations, and the Sewage Treatment Plant Phase III Upgrade project, all of which were described in Section 2.2.2. Because the meteorological conditions that would affect dispersion may have been significantly different from annual conditions during the short time periods in which these projects occurred, these projects were modeled using only meteorological data for the appropriate project timeframes.

Table 4-2

Americium-241 Non-Point Source Model Input Data<sup>a</sup>

Isopleth No.	Area (m <sup>2</sup> )	Distance to MEI (m) <sup>b</sup>	Direction to MEI <sup>b</sup>
Isopleth 1	8,435,258	4,565	NNE
Isopleth 2	95,570	3,768	NNE
Isopleth 3	2,978,028	3,768	NNE
Isopleth 4	116,806	4,107	NNE
Isopleth 5	4,354	4,126	NNE
Isopleth 6	42,732	4,232	NE
Isopleth 7	1,901,048	4,243	NE
Isopleth 8	87,078	4,243	NE
Isopleth 9	4,477	4,240	NE
Isopleth 10	5,414	3,388	NE
Isopleth 11	305,065	3,934	NE
Isopleth 12	27,106	3,928	NE
Isopleth 13	217,109	3,978	NE
Isopleth 14	12,556	4,026	NE
Isopleth 15	104,835	4,198	NE
Isopleth 16	64,360	4,779	N
Isopleth 17	34,105	3,767	NNE
Isopleth 18	7,504	3,792	NNE

<sup>a</sup> All non-point sources were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity).

<sup>b</sup> From isopleth centroids.

Notes:

- m = Meters
- m<sup>2</sup> = Square meters
- m/s = Meters per second
- MEI = Maximally exposed individual

Table 4-3

Plutonium-239/240 Non-Point Source Model Input Data<sup>a</sup>

Isopleth No.	Area (m <sup>2</sup> )	Distance to MEI (m) <sup>b</sup>	Direction to MEI
Isopleth 1	20,706,106	4,487	NE
Isopleth 2	188,186	4,109	NNE
Isopleth 3	6,475,068	3,947	NNE
Isopleth 4	267,835	3,778	NNE
Isopleth 5	4,966,529	3,839	NNE
Isopleth 6	131,338	4,120	NNE
Isopleth 7	222,993	4,134	NNE
Isopleth 8	2,187,390	4,162	NNE
Isopleth 9	18,185	4,219	NE
Isopleth 10	1,124,776	4,239	NE
Isopleth 11	107,203	4,241	NE
Isopleth 12	11,518	4,014	NE
Isopleth 13	64,337	3,972	NE
Isopleth 14	379,920	3,325	NE
Isopleth 15	24,270	5,460	NE
Isopleth 16	285,832	4,786	N
Isopleth 17	191,315	4,589	NNE
Isopleth 18	83,574	3,328	N
Isopleth 19	41,276	3,734	NNE
Isopleth 20	11,221	3,345	NNE

<sup>a</sup> All non-point sources were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity).

<sup>b</sup> From isopleth centroids.

Notes:

- m = Meters
- m<sup>2</sup> = Square meters
- m/s = Meters per second
- MEI = Maximally exposed individual

Table 4-4

Uranium-233/234 Non-Point Source Model Input Data<sup>a</sup>

Isopleth No.	Area (m <sup>2</sup> )	Distance to MEI (m) <sup>b</sup>	Direction to MEI <sup>b</sup>
Isopleth 1	3,444	5,372	NE
Isopleth 2	34,942	5,371	NE
Isopleth 3	3,475	5,369	NE
Isopleth 4	22,714	5,366	NE
Isopleth 5	23,320	5,457	NE
Isopleth 6	2,356	5,466	NE
Isopleth 7	16,505	5,477	NE
Isopleth 8	12,384	5,482	NE
Isopleth 9	905	5,486	NE
Isopleth 10	12,012	5,924	NE
Isopleth 11	7,257	5,926	NE
Isopleth 12	262	5,922	NE
Isopleth 13	3,032	3,970	NE

<sup>a</sup> All non-point sources were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity).

<sup>b</sup> From isopleth centroids.

Notes:

m = Meters  
 m<sup>2</sup> = Square meters  
 m/s = Meters per second  
 MEI = Maximally exposed individual

Table 4-5

Uranium-235 Non-Point Source Model Input Data<sup>a</sup>

Isopleth No.	Area (m <sup>2</sup> )	Distance to MEI (m) <sup>b</sup>	Direction to MEI <sup>b</sup>
Isopleth 1	13,336	5,476	NE
Isopleth 2	1,008	5,481	NE
Isopleth 3	8,033	5,486	NE
Isopleth 4	270	5,369	NE
Isopleth 5	2,513	5,367	NE

<sup>a</sup> All non-point sources were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity).

<sup>b</sup> From isopleth centroids.

Notes:

m = Meters  
 m<sup>2</sup> = Square meters  
 m/s = Meters per second  
 MEI = Maximally exposed individual

Table 4-6

Uranium-238 Non-Point Source Model Input Data<sup>a</sup>

Isopleth No.	Area (m <sup>2</sup> )	Distance to MEI (m) <sup>b</sup>	Direction to MEI <sup>b</sup>
Isopleth 1	53	4,225	NE
Isopleth 2	1,171	4,425	NE
Isopleth 3	8,299	4,281	NE
Isopleth 4	7,254	4,188	NE
Isopleth 5	2,969	5,347	NE
Isopleth 6	314	5,344	NE
Isopleth 7	795	5,859	NE

<sup>a</sup> All non-point sources were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity).

<sup>b</sup> From isopleth centroids.

Notes:

- m = Meters
- m<sup>2</sup> = Square meters
- m/s = Meters per second
- MEI = Maximally exposed individual

Table 4-7

Source Data for Model Input--Non-Point Sources

Parameter	T-3 Excavation/Backfill Values	T-4 Excavation/Backfill Values	Sewage Treatment Plant Phase III Upgrade Values
Height (m)	0	0	0
Area (m <sup>2</sup> )	249	232	93
Exit Velocity (m/s)	0	0	0
Distance to MEI (m)	3,772	3,772	4,401
Direction to MEI	NE	NE	NE

Notes:

- m = Meters
- m<sup>2</sup> = Square meters
- m/s = Meters per second
- MEI = Maximally exposed individual

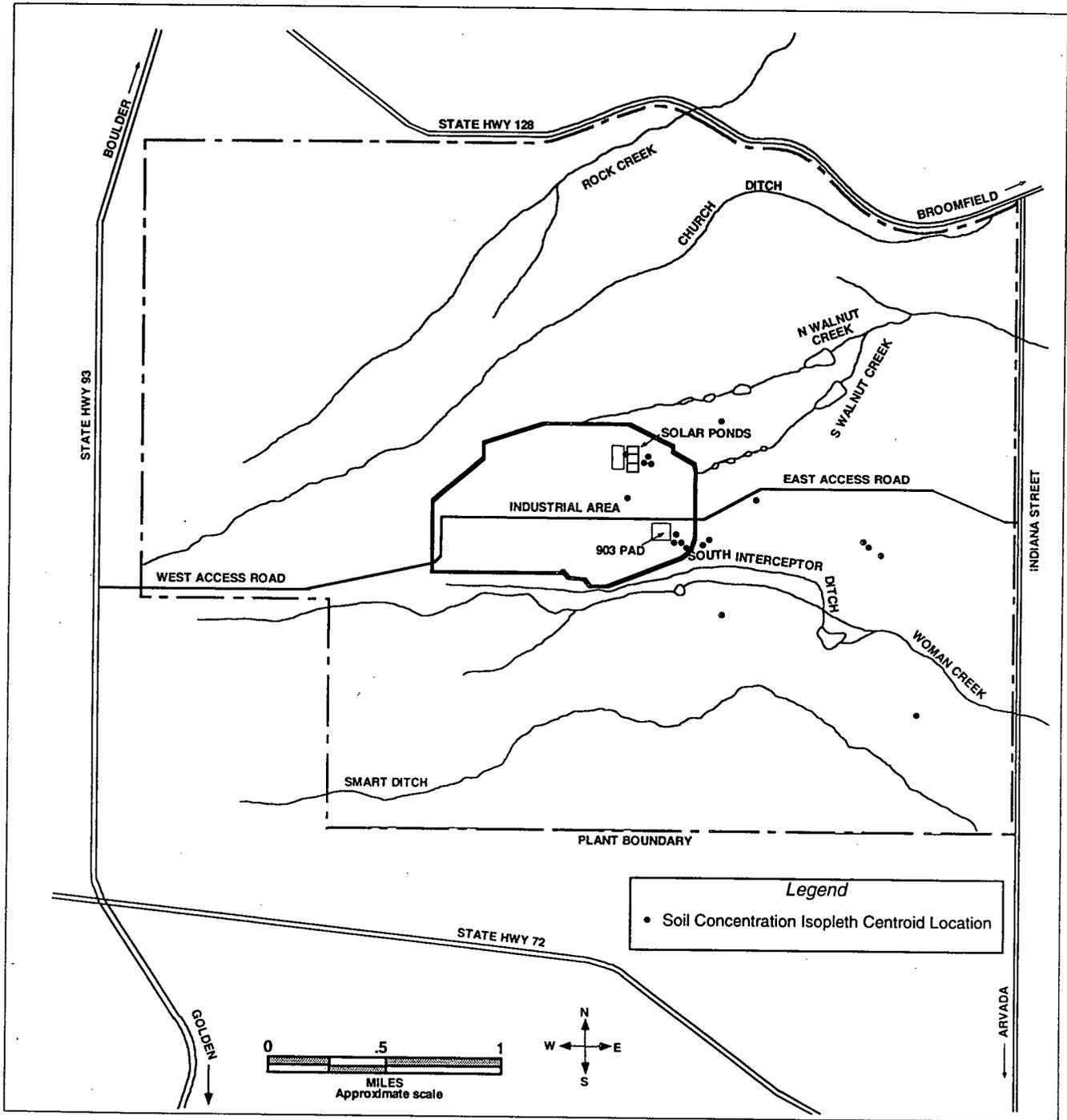
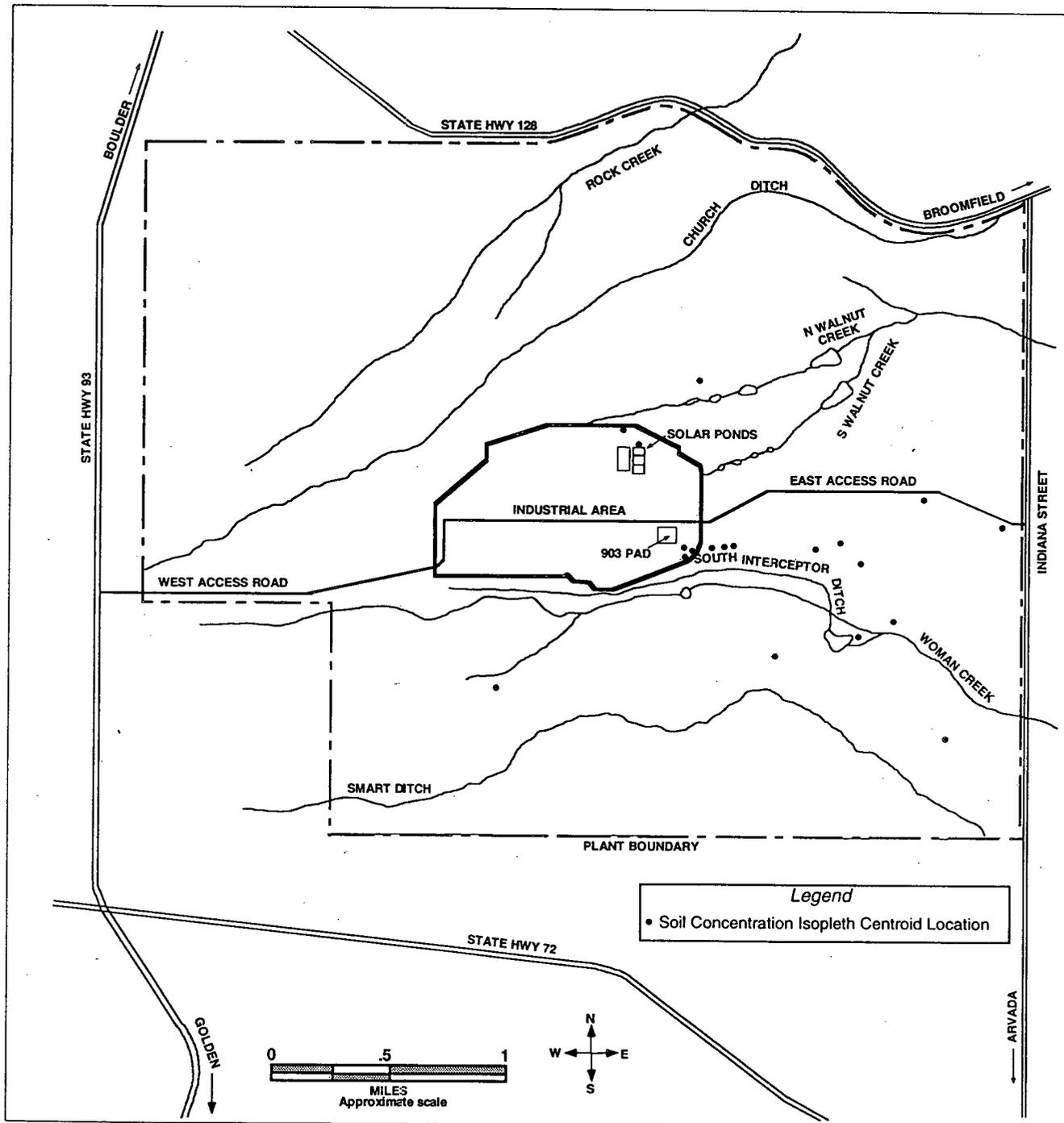


Figure 4-4. Soil Concentration Isopleth Centroid Locations for Americium-241



**Figure 4-5. Soil Concentration Isopleth Centroid Locations for Plutonium-239 and Plutonium-240**

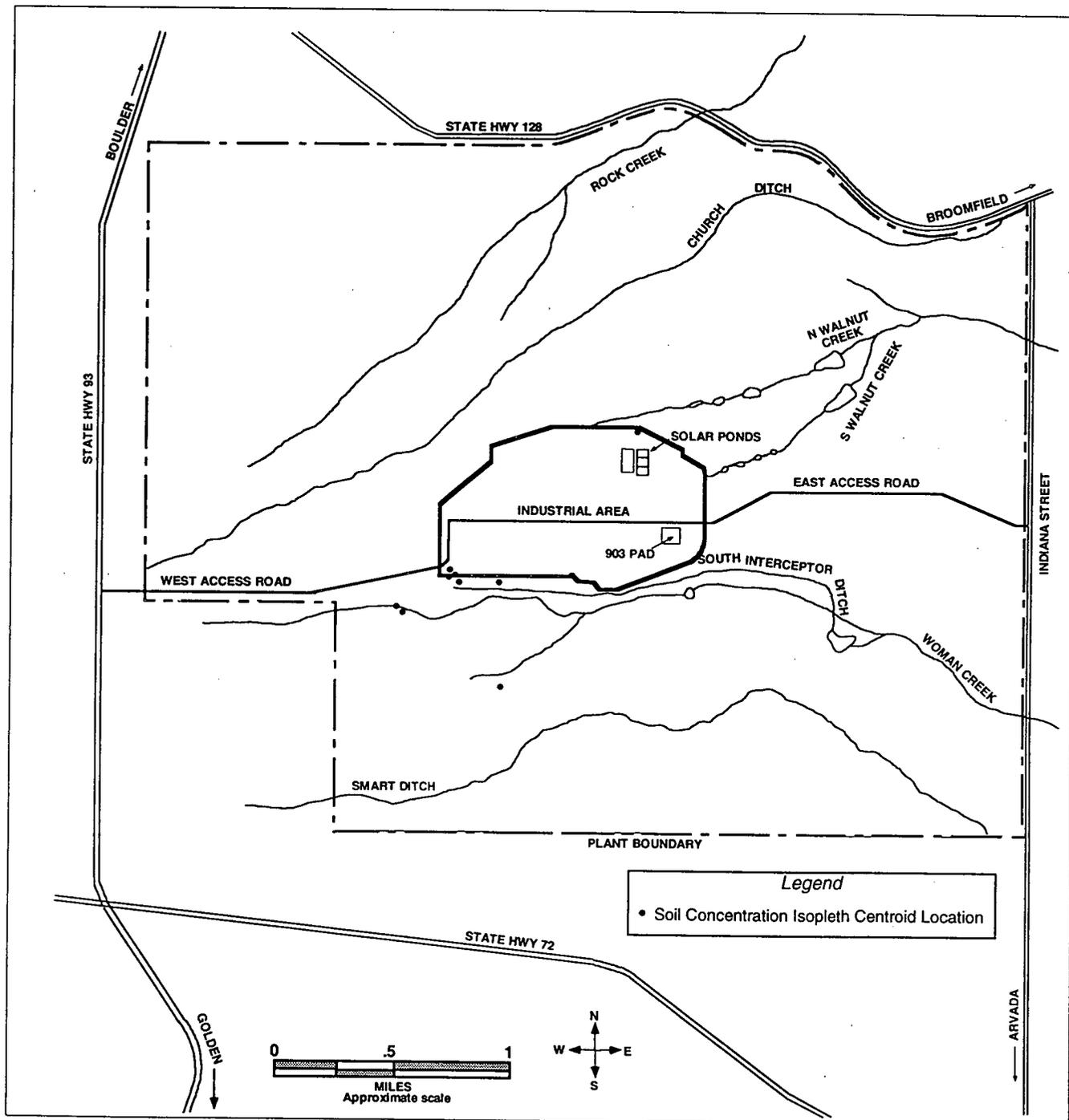


Figure 4-6. Soil Concentration Isopleth Centroid Locations for Uranium-233 and Uranium-234

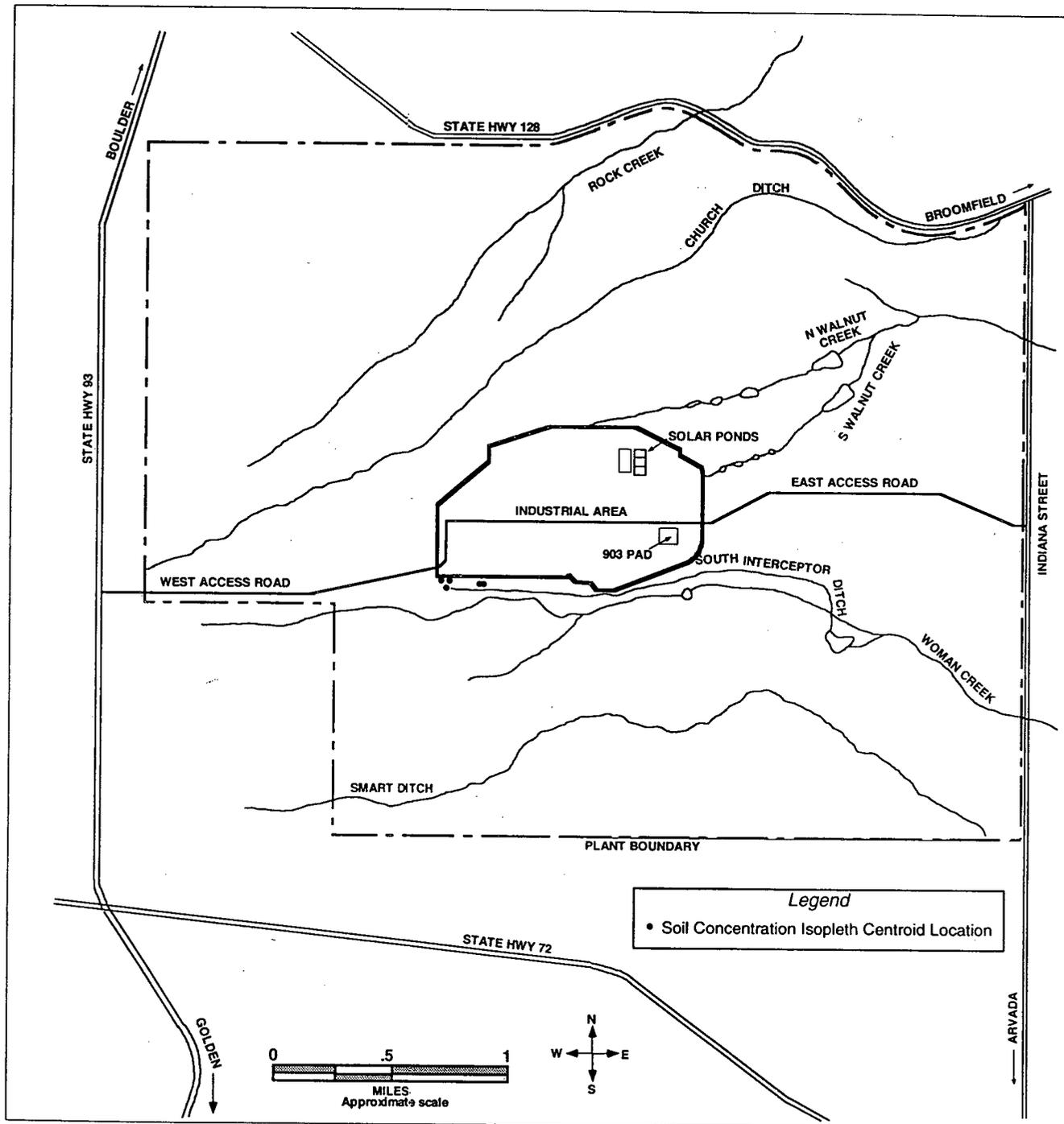


Figure 4-7. Soil Concentration Isopleth Centroid Locations for Uranium-235

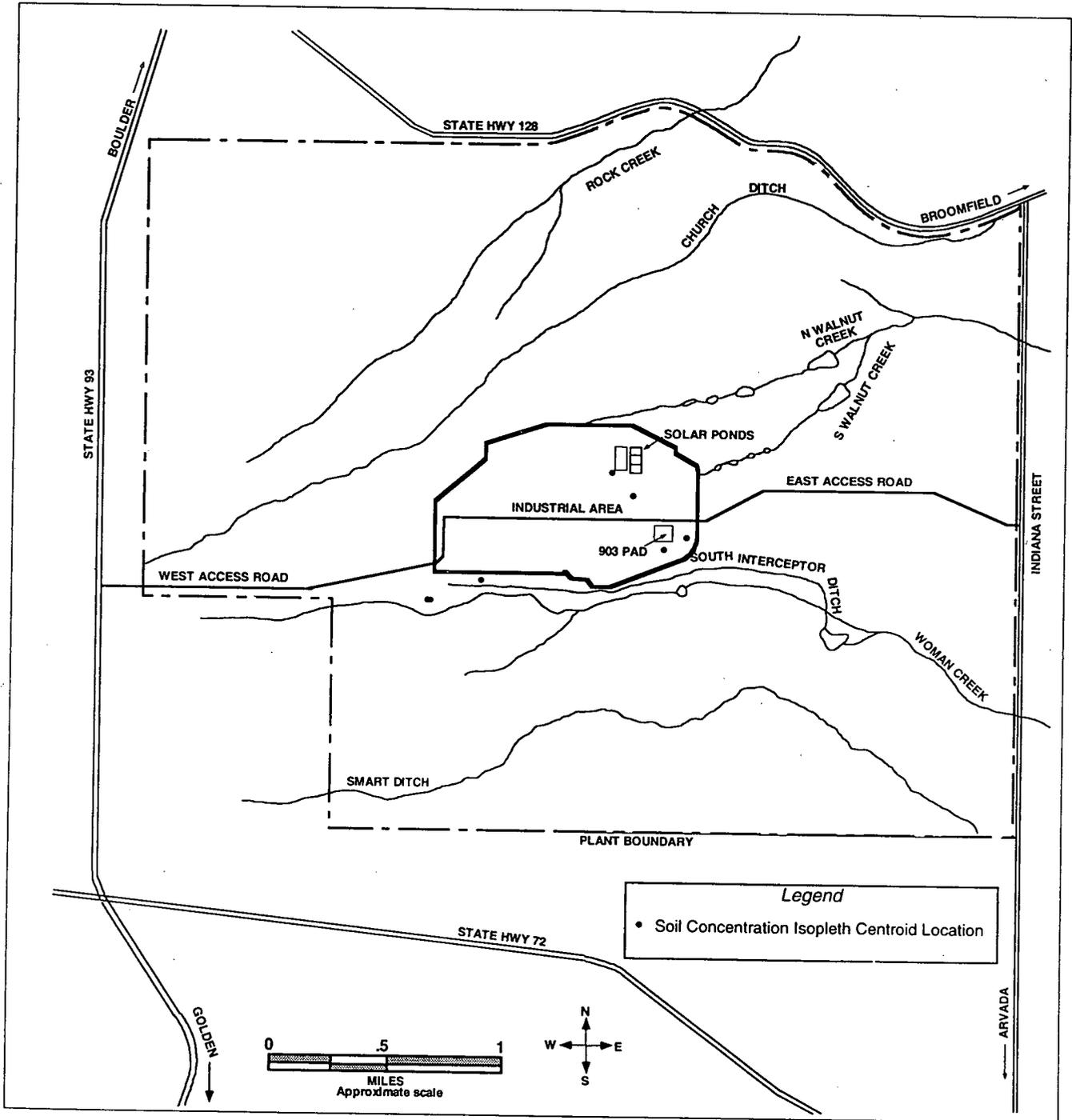


Figure 4-8. Soil Concentration Isopleth Centroid Locations for Uranium-238



Separate CAP-88 meteorological data files were developed for the two one-week periods used in modeling T-3/T-4 project emissions, for the month during which the T-2 TDU operated, and for the two-month period representing the Sewage Treatment Plant Phase III Upgrade project. These wind roses are shown in Figures 4-10 through 4-13.

Annual precipitation and temperature data for calendar year 1996, the T-3/T-4 modeling period, the T-2 TDU modeling period, and the Sewage Treatment Plant Phase III Upgrade modeling period are summarized in Table 4-8. These data were also collected on Site. An average mixing height for the Denver, Colorado, area of 1,405 m was used in the model (EPA, 1972).

#### **4.2.5 Other Input Data**

The CAP88-PC model also requires other input data. Model default values were used for the median aerodynamic diameter (1.0  $\mu\text{m}$ ) and solubility class. Urban agricultural data were used in the model and are shown in Table 4-9. Default values were also used for the origin of food products, as shown in Table 4-10.

The shortest distance between a Site radionuclide release point and farmland producing agricultural products is 720 m for beef cattle, 5,228 m for dairy cattle, and 1,063 m for cropland.

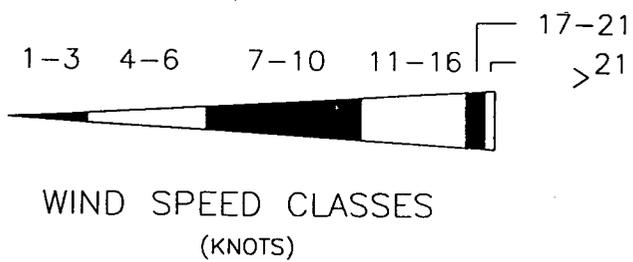
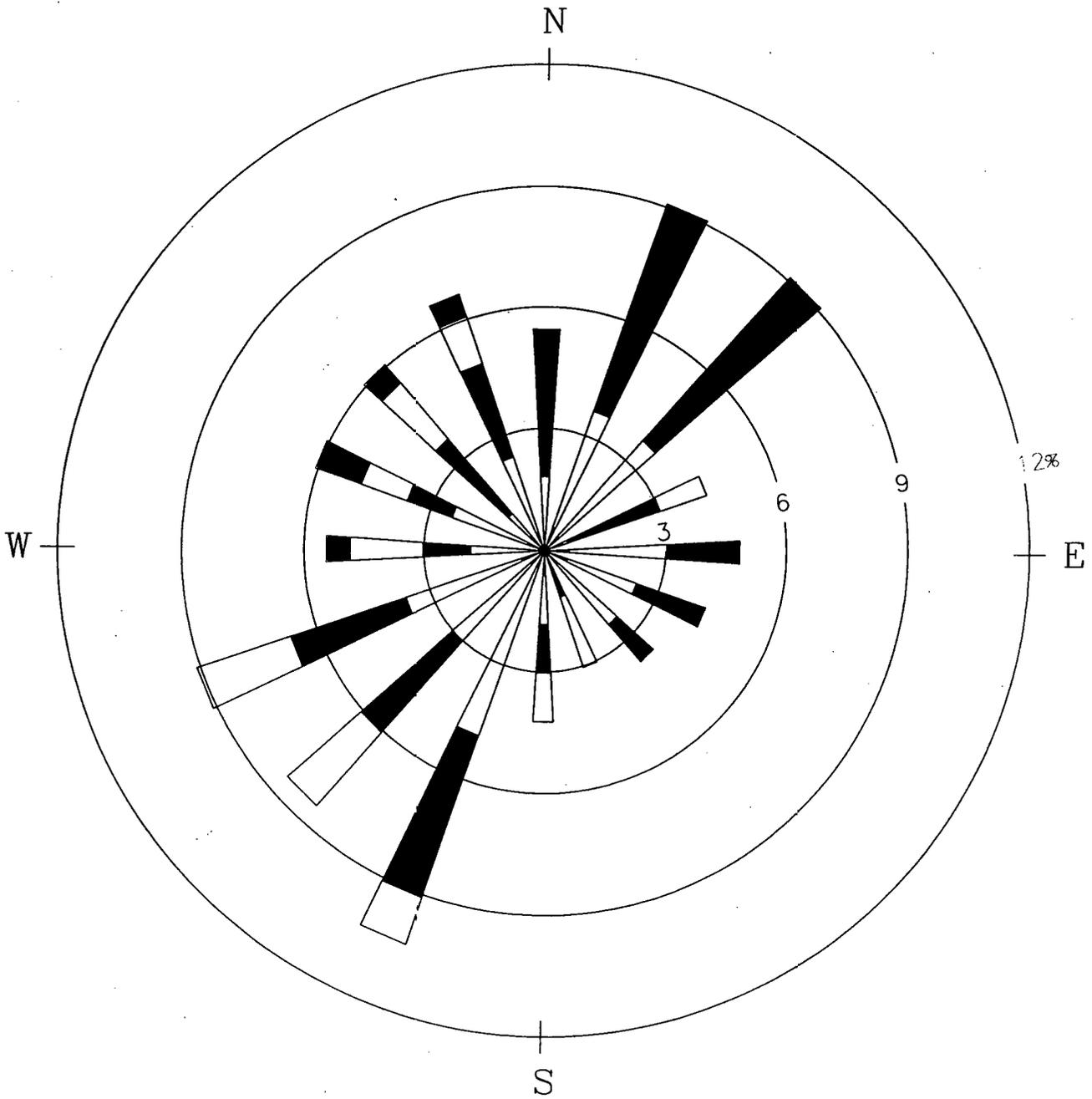
Appendix E summarizes the model input data used for this assessment.

#### **4.3 Compliance Assessment**

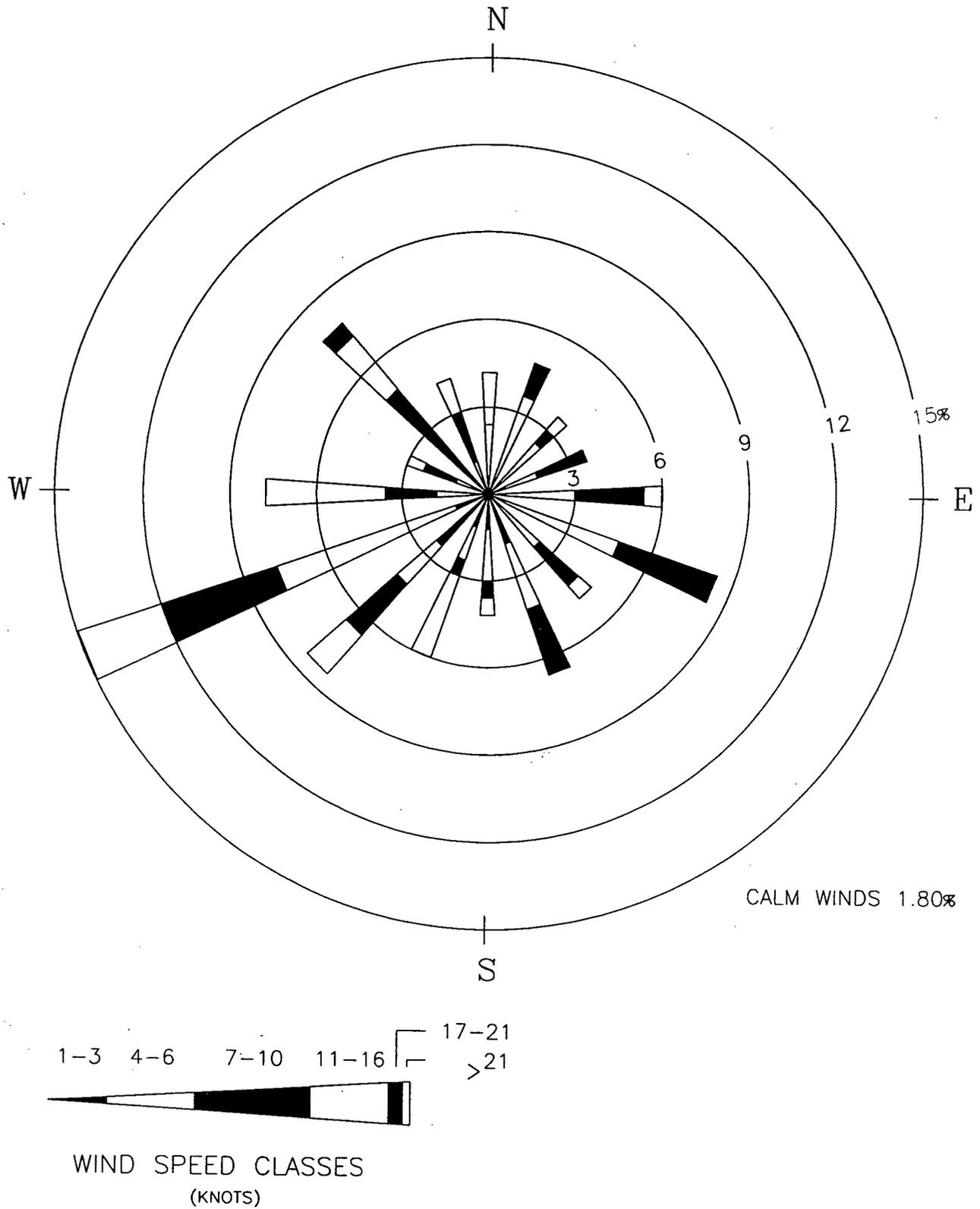
The EDEs calculated for each modeled emission source were summed for each receptor and the MEI determined. The maximum off-Site calendar year 1996 EDE from all Site emissions was 0.182 mrem (0.00182 mSv), approximately 1.8% of the 10 mrem (0.1 mSv) standard. The MEI was located along McCaslin Boulevard, 4,425 m to the northeast of the center of the Site's industrial area.

While the total dose to the public in 1996 was well within the standard, it represents an increase from calendar year 1995, when a maximum annual off-Site EDE of 0.0078 (0.000078 mSv) was reported. In addition, changes in the location of maximum impact, the relative contribution of various isotopes, and the type of emission sources driving the dose resulted from the changing nature of Site activities.

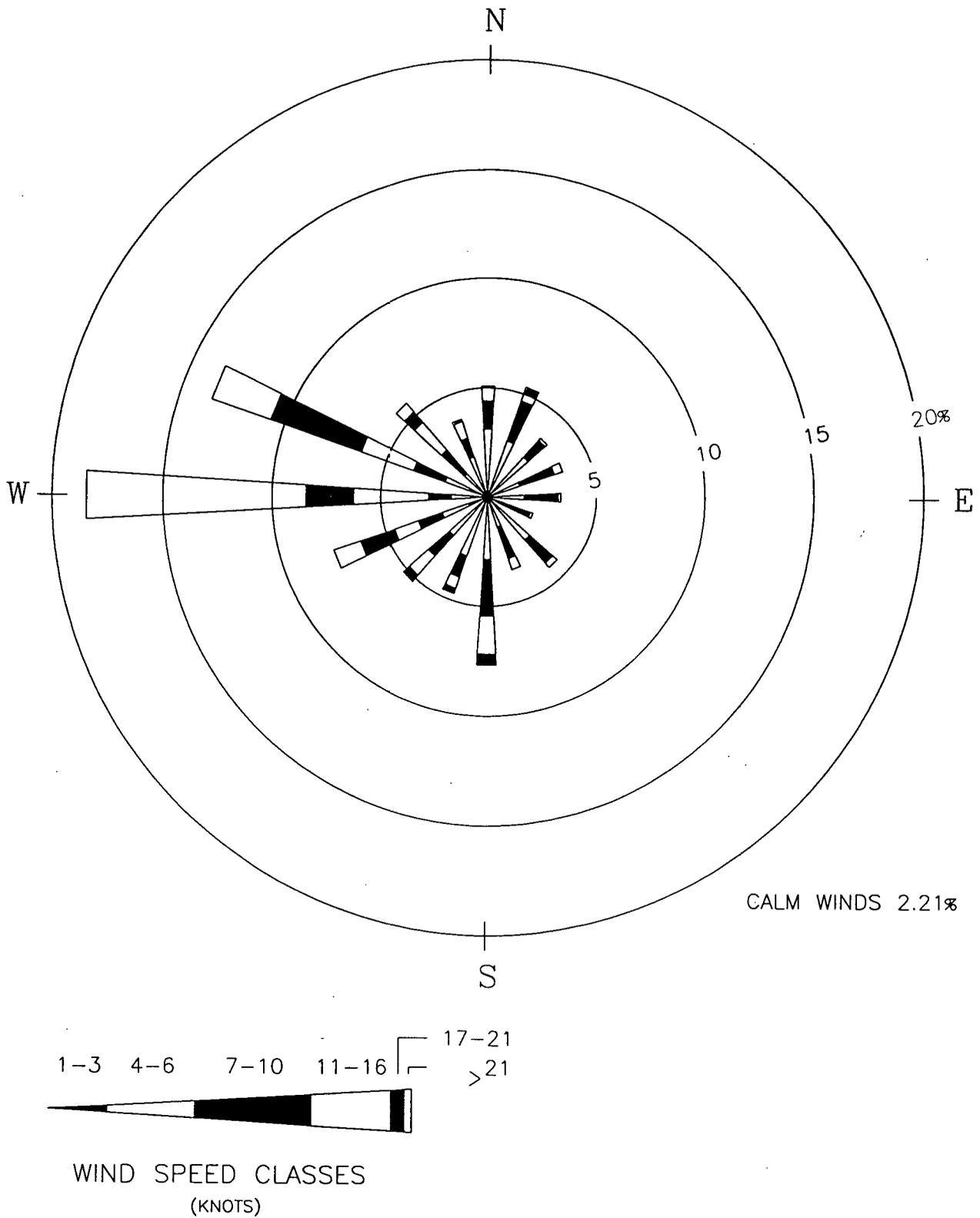
The contributions of various emission source types to the maximum annual off-Site EDE for 1996 are shown in Figure 4-14. The T-3/T-4 remediation project contributed over 93% of the MEI dose in 1996. Two additional projects that handled radionuclide-contaminated soil, the Sewage Treatment Plant Phase III Upgrade and thermal treatment of contaminated soils from T-2, each contributed more to the



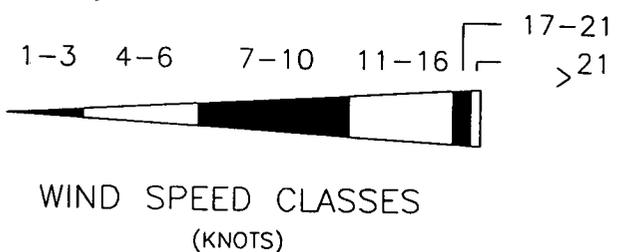
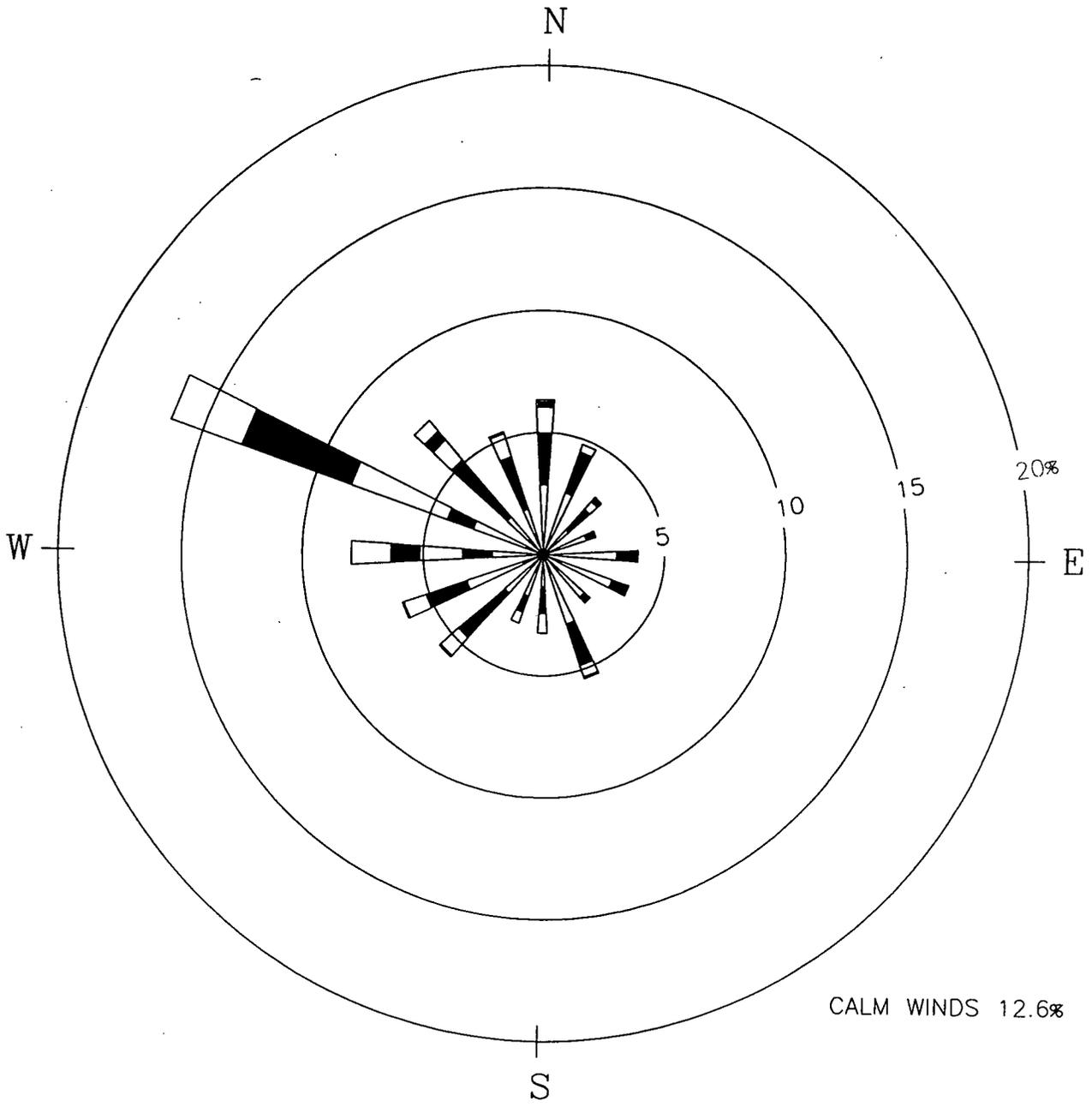
**Figure 4-10. Wind Frequency Distribution - Trench 3**



**Figure 4-11. Wind Frequency Distribution - Trench 4**



**Figure 4-12. Wind Frequency Distribution - Trench 2 Thermal Treatment**



**Figure 4-13. Wind Frequency Distribution - Sewage Treatment Plant Phase III Upgrade**

Table 4-8

Additional Meteorological Data for Model Input

Input	Annual	T-3	T-4	T-2 TDU	Sewage Treatment Plant Phase III Upgrade
Wind Data <sup>a</sup>	Jan 1 - Dec 31, 1996	Jul 30 - Aug 6, 1996	Sep 3 - Sep 9, 1996	Jan 15 - Feb 15, 1996	Sep 22 - Nov 15, 1996
Total Precipitation <sup>b</sup>	36.47 cm	0.36 cm	1.27 cm	2.21 cm	3.66 cm
Average Temperature <sup>c</sup>	8.9°C	21.7°C	18.8°C	-2.0°C	8.24°C
Mixing Height <sup>d</sup>	1,405 m	1,405 m	1,405 m	1,405 m	1,405 m

<sup>a</sup> From on-site tower at 10 m height.

<sup>b</sup> Total precipitation equivalent for time period (rainfall and snowfall).

<sup>c</sup> Average of monthly/daily average temperatures.

<sup>d</sup> Average of annual morning and afternoon mixing heights for Denver from "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States," US EPA, Office of Air Programs, Research Triangle Park, NC, January 1972

Notes:

- cm = Centimeter
- m = Meter
- °C = Degrees Celsius
- US EPA = U.S. Environmental Protection Agency
- TDU = Thermal desorption unit

Table 4-9

Agricultural Data for Model Input

Input	Value Used
Source	Urban
Beef Cattle Density <sup>a</sup>	1.13 E-01 cattle/km <sup>2</sup>
Milk Cattle Density <sup>a</sup>	3.50 E-03 cattle/km <sup>2</sup>
Land Fraction Cultivated for Vegetable Crops <sup>a</sup>	1.39 E-02

<sup>a</sup> Model default values.

Note:

km<sup>2</sup> = Square kilometers  
 E# = x 10<sup>#</sup>

Table 4-10

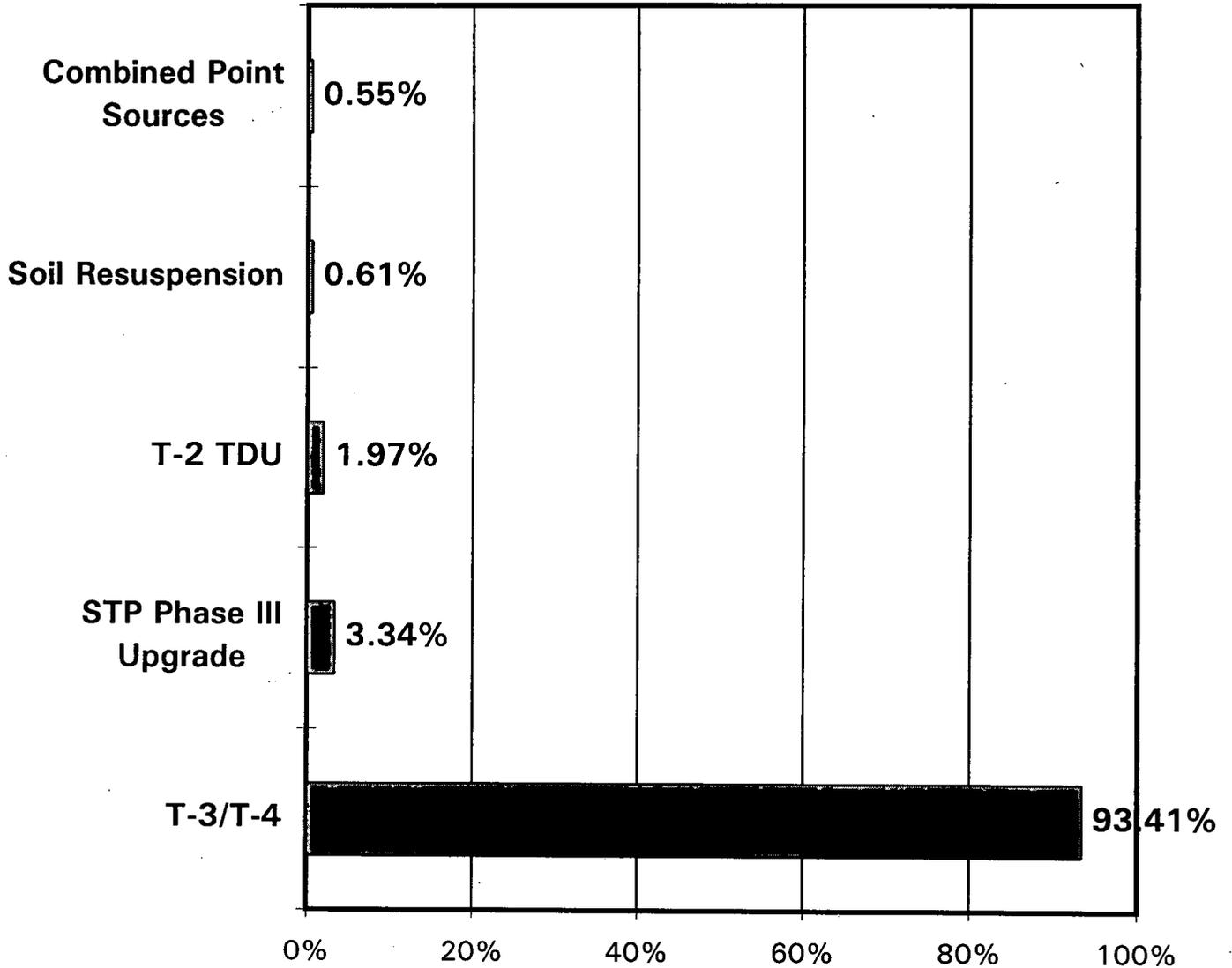
Origin of Food Products

Origin	Food Product		
	Vegetable	Milk	Beef
Fraction From Home Produced <sup>a</sup>	0.076	0.0	0.008
Fraction From Assessment Area <sup>a</sup>	0.924	1.0	0.992
Fraction Imported <sup>a</sup>	0.0	0.0	0.0

<sup>a</sup> Model default values.

Figure 4-14.

Contribution to 1996 Maximum Off-Site EDE by Source Type



Notes:

- EDE = Effective Dose Equivalent
- TDU = Thermal desorption unit
- STP = Sewage Treatment Plant

MEI dose than either wind-blown soil contamination or the combined emissions of all other Site point sources.

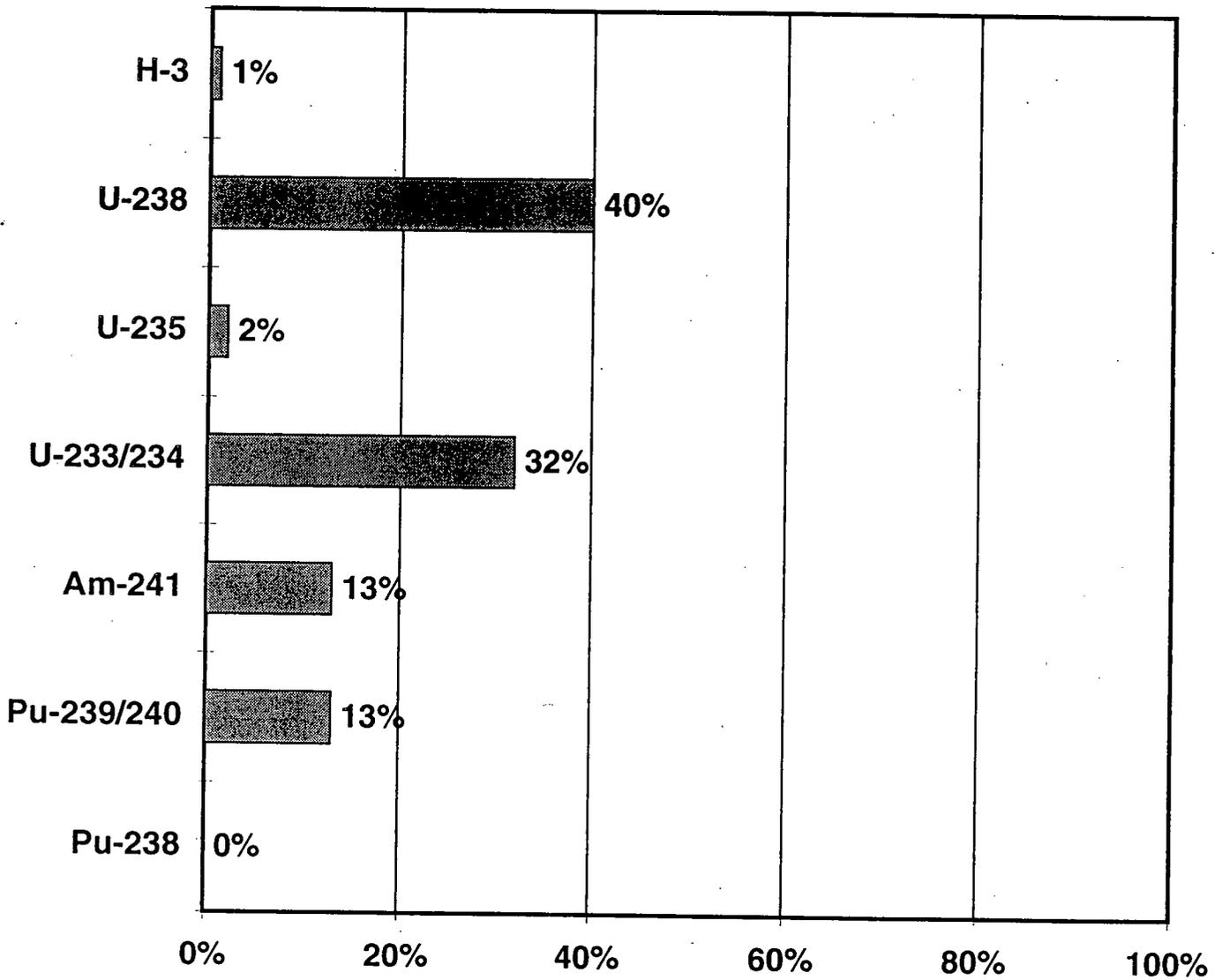
As cleanup of the Site continues, the Site air emission and dose profile will be increasingly dominated by projects that disturb contaminated soil or debris. In many cases, these cleanup activities will involve much smaller amounts of radionuclides than are stored or handled inside Site buildings. However, the nature of remediation activities is such that emissions cannot be reduced to the same extent as emissions from activities taking place under controlled conditions inside structures.

A graph portraying the contribution from each isotope to the EDE at the MEI location is shown in Figure 4-15. The contribution of various isotopes to the total 1996 dose differs from the contributions in 1995. The 1995 dose was dominated by Pu-239/240 and Am-241 in soils associated with the excavation of T-2 and in routine emissions of wind-blown dust from other areas of contamination on Site. The 1996 dose was instead dominated by uranium isotopes associated with the T-3/T-4 remediation. T-3/T-4 soils and debris also represented the major sources of Pu-239/240 and Am-241 air emissions from the Site in 1996.

The MEI location has also changed from previous years. In past years, the location of maximum off-Site impact has been tied to annual average wind patterns. The 1996 maximum impact location, in contrast, was heavily influenced by the wind patterns that occurred over the shorter timeframe during peak T-3/T-4 activities.

Figure 4-15.

Contribution to 1996 Maximum Off-Site EDE by Isotope



Notes:

- Am = Americium
- EDE = Effective Dose Equivalent
- H-3 = Tritium
- Pu = Plutonium
- U = Uranium

#### 4.4 Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. (See 18 U.S.C. 1001.)

Keith Klein  
Deputy Manager, Rocky Flats Field Office  
  
Department of Energy

John A. Hill  
Vice President, Environmental Management &  
Compliance  
Kaiser-Hill Company, L.L.C.

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Signature

Date

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Signature

Date



## 5.0 SUPPLEMENTAL INFORMATION

The following information is provided pursuant to DOE guidance and is not required by 40 CFR 61, Subpart H, or Regulation No. 8, Part A, Subpart H, reporting requirements.

- Calendar year 1996 dose at non-MEI locations: The maximum EDE to the public for the 1996 calendar year was 0.182 mrem (0.00182 mSv) for a receptor located along McCaslin Boulevard, 4,425 m to the northeast of the center of the Site. Annual EDE estimates for the closest receptor locations in other directions from the center of the Site are shown in Table 5-1 for comparison.
- Calendar year 1996 collective dose: The collective dose to the surrounding population was calculated with CAP88-PC using population figures that were adjusted from 1994 data based on regional growth information. The collective dose represents the total dose to the surrounding population within 52 miles (83.7 km) of the Site. The collective dose for the 1996 calendar year was 10.5 person-rem (0.105 person-Sv).
- Other radionuclide regulations: 40 CFR 61, Subparts T and Q (Regulation No. 8, Part A, Subparts T and Q) are not applicable to this Site. Subparts T and Q contain standards for radon emissions from specific facilities.
- Unplanned releases: There were no unplanned releases of radionuclides to the atmosphere from the Site during 1996. However, monitoring data showed that radionuclide emissions from the T-3/T-4 remediation were higher than initially estimated, as discussed below.
- Modeling/monitoring data comparison for T-3/T-4 project: As discussed in Section 3.3.1, ambient monitoring data taken during the T-3/T-4 remediation project indicated that the emissions estimated prior to project startup were low. Emission estimates were revised following project completion based on DOE airborne release fraction data (DOE, 1994) and project-specific schedule and activity data. Revised emissions were calculated based both on average contamination levels in project soils and on the maximum radionuclide concentrations measured in soils from the trenches. The primary radionuclides emitted from the T-3/T-4 project were various uranium isotopes.

A revised modeling analysis was performed with CAP88-PC using meteorological data for the two weeks during which maximum project emissions occurred (determined from radionuclide monitoring conducted by CDPHE adjacent to the project site) and revised emission estimates. The T-3/T-4 project took place immediately east of the central, industrial portion of the Site and the winds were generally from the southwest, west, and northwest during that time. The

Table 5-1

Calendar Year 1996 Dose at  
Receptor Locations Surrounding the Site

Location	1996 EDE (mrem)	Distance to Receptor <sup>a</sup> (m)	Direction to Receptor <sup>a</sup>
McCaslin Blvd. (MEI)	0.182	4,425	NE
Mower Reservoir	0.161	4,143	ESE
East of Great Western Reservoir	0.136	5,695	E
96th Ave. and Indiana St.	0.128	4,064	SE
Sawmill, east of Highway 93	0.104	2,994	WNW
South, at Highway 72	0.092	3,419	S
Rocky Flats Lake	0.090	3,625	SW

<sup>a</sup> From center of Site industrial area.

Notes:

EDE = Effective dose equivalent  
m = Meters  
MEI = Maximally exposed individual  
mrem = Millirem

maximum concentrations for the short-term modeling scenario were estimated for a receptor located northeast on the Site; however, concentrations estimated for receptors to the east and southeast of the Site were of a comparable magnitude.

Radionuclide concentrations in air are routinely monitored at several locations. The revised modeling analysis estimated uranium isotope concentrations at two of these monitoring locations. The S-137 monitor is located near the Site's east access gate; S-158 is located to the southeast of the Site near Standley Lake. Modeled uranium isotope concentrations due to the T-3/T-4 project are compared to contemporaneous measured concentrations of uranium at these monitors in Table 5-2.

The data recorded at S-137 and S-158 represent monthly average radionuclide concentrations in the air at the monitor locations. For each location and isotope, Table 5-2 shows both the average of the four monthly concentrations recorded during the T-3/T-4 project (June through September, 1996) and the average of the concentrations recorded for the two months during which maximum project emissions occurred (July and September, 1996).

Table 5-2 shows that uranium concentration estimates from the revised modeling analysis for T-3/T-4 are in reasonable agreement with measured uranium concentrations at S-137 and S-158. In general, monitored concentrations were slightly higher than modeled values, even those based on the maximum contamination levels measured in project soils. It should be noted that the monitored values reflect total Site emissions, while the modeling analysis shown in Table 5-2 only represents emissions from the T-3/T-4 project. However, the dose analysis performed for this report shows that T-3/T-4 emissions were likely several orders of magnitude greater than emissions from other Site sources during the project timeframe.

- Sitewide modeling/monitoring data comparison for calendar year 1996: As discussed below, the Site is proposing an alternative compliance demonstration method for 40 CFR 61, Subpart H (CAQCC Regulation No. 8, Part A, Subpart H). The proposed method will demonstrate compliance by comparing monitored air concentrations of radioisotopes to concentration levels listed in Appendix E to 40 CFR 61 (CAQCC Regulation No. 8, Part A). A limited comparison of 1996 monitoring data to Appendix E values can be made, using monitored and modeled Pu-239 results.

Under the alternative compliance demonstration method, compliance with the 10 mrem (0.1 mSv) annual standard will be assessed by comparing monitored concentrations of individual isotopes to allowable concentrations for each isotope listed in Table 2 of Appendix E (to 40 CFR 61 and CAQCC Regulation No. 8, Part A), and by summing fractional values of allowable concentrations for each isotope. Compliance will be demonstrated if the monitored

Table 5-2

Comparison of Modeled and Monitored  
Radionuclide Concentrations for T-3/T-4 Project

Location <sup>a</sup>	Isotope	Modeled Concentrations <sup>b</sup>		Measured Concentrations <sup>c</sup>	
		Average Emissions (pCi/m <sup>3</sup> )	Maximum Emissions (pCi/m <sup>3</sup> )	4-Month Average (pCi/m <sup>3</sup> )	Jul & Sep Average (pCi/m <sup>3</sup> )
Near Site East Gate (S-137)	U-233/234	4.55 E-06	6.82 E-05	3.08 E-05	3.62 E-05
	U-238	5.12 E-06	9.42 E-05	8.59 E-05	1.38 E-04
Near Standley Lake (S-158)	U-233/234	1.45 E-06	8.69 E-06	1.99 E-05	2.02 E-05
	U-238	9.30 E-07	1.22 E-05	5.48 E-05	7.26 E-05

<sup>a</sup> The S-137 monitor is located near the Site's east access gate; S-158 is located southwest of the Site near Standley Lake.

<sup>b</sup> Modeled concentrations are presented based on emission estimates using both average and maximum radionuclide concentrations in project soils.

<sup>c</sup> Measured concentrations represent either a four-month average (June through September, 1996, representing the full duration of T-3/T-4 project emissions) or an average of July and September, 1996 monitoring data (representing the months when maximum project emissions occurred).

Notes:

Jul = July  
 pCi/m<sup>3</sup> = PicoCuries per cubic meter  
 Sep = September  
 U = Uranium  
 E# = x10<sup>#</sup>

concentration for each individual isotope is less than the concentration value listed in Table 2 of Appendix E and if the sum of the fractional values is less than 1.

For 1996, the only comparison that can be made is for the Pu-239 isotope. Three ambient samplers located at the perimeter of the Site collected Pu-239 concentration data during the entire 1996 calendar year. Pu-239 concentrations measured at the S-138 and S-207 monitors are compared to 1996 calendar year concentration estimates from CAP88-PC modeling at the closest receptor locations in Table 5-3. S-138 is located 3,443 m east-southeast of the center of the Site; the corresponding receptor location is at Mower Reservoir, approximately 800 m further east. S-207 is located 4,064 m southeast of the center of the Site; the corresponding receptor location is at 96th Avenue and Indiana Street, just to the east of the monitor. For calendar year 1996, the modeled concentrations were somewhat higher than measured concentrations at these two monitors.

Table 5-3 also shows a comparison of annual average Pu-239 concentrations measured at these two monitors with the corresponding Table 2 Pu-239 value from Appendix E to 40 CFR 61 and CAQCC Regulation No. 8, Part A. Had additional isotopes been measured in 1996, the sum of fractional contributions of each measured isotopic concentration would yield the total dose fraction used to determine compliance with the 10 mrem (0.1 mSv) public dose standard.

- Basis of alternative method for compliance demonstration: As the Site continues to work toward cleanup and closure, buildings that contain significant quantities of radionuclide materials will be deactivated. Special nuclear material and radionuclide wastes will be removed from the buildings, and a limited cleanup of removable contamination will be performed. This phase of the cleanup will not, however, include complete removal of contamination from gloveboxes or ductwork. Following the limited contaminant removal, the ventilation systems will be sealed with wrap or other materials and then turned off. The exhaust exits will be sealed and the buildings closed, pending future decontamination and demolition. Small HEPA-filtered, passive vents will be installed to allow the ducts to breathe under natural changes in temperature and atmospheric pressure.

In some cases, the deactivated buildings may contain enough potentially dispersible contamination to exceed the annual monitoring threshold of 0.1 mrem (0.001 mSv) based on potential uncontrolled emissions. With the ventilation turned off and the ducts and vents sealed, there will be no directed flow from the contaminated areas, thereby precluding normal effluent monitoring. Such buildings will become non-point (diffuse) sources of airborne radionuclides.

**Table 5-3**

**Calendar Year 1996 Monitored and Modeled Pu-239 Concentrations**

Location <sup>a</sup>	Parameter	Modeled	Measured
Mower Reservoir (Modeled)	Concentration (Ci/m <sup>3</sup> )	5.4 E-18	1.1 E-18
S-138 (Measured)	Fraction of Appendix E Standard <sup>b</sup>	--	0.00055
96th and Indiana (Modeled)	Concentration (Ci/m <sup>3</sup> )	3.4 E-18	9.2 E-19
S-207 (Measured)	Fraction of Appendix E Standard <sup>b</sup>	--	0.00046

<sup>a</sup> S-138 is located on the Site perimeter 3,443 m east-southeast of the Site center; Mower Reservoir is 800 m east of S-138. S-207 is located on the Site perimeter, 4,064 m southeast of the Site center; 96th and Indiana is located just east of S-207.

<sup>b</sup> Standard given in Table 2, Appendix E, 40 CFR 61 (CAQCC Regulation No. 8, Part A) for Pu-239 is 2.0 E-15 Ci/m<sup>3</sup>.

Notes:

- Pu = Plutonium
- CAQCC = Colorado Air Quality Control Commission
- CFR = Code of Federal Regulations
- Ci/m<sup>3</sup> = Curies per cubic meter
- E# = x10<sup>#</sup>
- = Not applicable

Another substantial component of Site cleanup will be the remediation of contaminated soils. The excavation and handling of radionuclide-contaminated soil and debris will also generate radionuclide emissions that cannot be directly measured.

As the Site progresses toward ultimate closure, the number of diffuse sources is expected to increase, and the number of active ducts amenable to normal effluent monitoring will decrease. As a result, the Site has proposed the use of environmental measurements as an alternative to air dispersion calculations to demonstrate compliance with the annual 10 mrem (0.1 mSv) standard, as allowed by 40 CFR 61.93(b)(5) (CAQCC Regulation No. 8, Part A, Section 61.93(b)(5)). Discussions with EPA and CDPHE have resolved many of the requirements for the alternative method and a formal proposal will be submitted to EPA for approval in 1997. The major aspects of the alternative compliance demonstration method that will be proposed include:

- An ambient monitoring network exists around the perimeter of the Site and in nearby communities. To the extent possible, this network will be employed to satisfy the requirements of the alternative environmental monitoring proposal. Modeled annual estimates of dose have shown that maximum Site impacts have historically occurred in sectors to the east of the Site, and existing monitors have been sited to provide coverage of those potential critical receptor locations.
- The ambient samplers collect both a fine and coarse particulate fraction continuously on filters and removable impactor surfaces that can be exchanged and analyzed on a monthly schedule. The samples will be analyzed for the plutonium, uranium, and americium isotopes that represent most of the radioactive materials handled and residing on the Site. These isotopes will account for all materials that have the potential to contribute 10% or more of the dose to the public. The resulting monthly concentration data at each of the monitoring locations will be compared with allowable concentration levels in Table 2 of Appendix E to 40 CFR 61 (CAQCC Regulation No. 8, Part A) and will be summed annually at each location for reporting to EPA and CDPHE.
- Effluent monitoring will be discontinued at insignificant point sources on Site and the ambient network will be used to demonstrate low emissions from those locations as required in Section 61.93(b)(4).
- Annual compliance data will be reported from all ambient sampling locations at the Site perimeter. The location with the highest annual radioisotope concentrations will be considered the "critical receptor" used to demonstrate compliance with the standard.

- Emissions from significant point source locations will continue to be monitored with effluent samplers. For a two-year transition period following approval of the alternative method, emissions from the Site will be modeled, including estimated diffuse source emissions, and the resulting EDE reported to allow comparison with environmental measurements. Compliance will be demonstrated using the alternative ambient network results.

• Status of compliance with EPA effluent monitoring requirements: The Site is in compliance with all requirements of 40 CFR 61, Subpart H, and Regulation No. 8, Part A, Subpart H, with the exception of Sections 61.93(b)(1) and 61.93(b)(2)(i):

- Compliance with Section 61.93(b)(1): The Site is in compliance at 17 of 21 volumetric flow rate locations. There are four locations that fail to satisfy the siting criteria of 40 CFR 60, Appendix A, Reference Method 1 (Regulation No. 6, Part A, Appendix A, Reference Method 1).
- Compliance with Section 61.93(b)(2)(i): Fourteen of 21 sampling sites comply with Reference Method 1 of Appendix A to 40 CFR 60 and Regulation No. 6, Part A. There are seven sampling locations at the Site that fail to satisfy the siting criteria of 40 CFR 61.93 (b)(2)(i) and Regulation No. 8, Part A, Section 61.93 (b)(2)(i).

Representative samples of the effluent stream are withdrawn continuously from each monitored sampling site following the guidance presented in American National Standards Institute (ANSI) N13.1-1969. Site air monitoring personnel believe that the current monitoring system is, and always has been, in compliance with the required monitoring protocols. Between approximately 1990 and 1994, the Site provided information requested by EPA, Region VIII, including information requested as part of a 1992 Administrative Compliance Order, to obtain an official determination as to whether the Site was in compliance with the required monitoring protocols. No final compliance determination has been issued by EPA, Region VIII, although, in a March 4, 1992 Environmental News release, EPA stated that "in the interim, EPA believes public health is being protected. Air sampling systems at the facility and air monitoring equipment surrounding the plant continue to provide information indicating that potential estimated exposures to area residents are hundreds of times below limits set in the National Emissions Standards for Hazardous Air Pollutants (NESHAPS)."

In the absence of an official determination, the Site offered and Region VIII approved the installation of an alternative shrouded probe monitoring methodology approved by both DOE headquarters (HQ) and EPA HQ. A schedule has been established for installation of this methodology at locations that require continuous monitoring. Engineering of the new shrouded

probe sampling systems is underway, with installation to be completed by December 1997. All sampling locations that fail to meet the siting criteria are scheduled to be modified to use the alternate shrouded probe method during this shrouded probe sampling system upgrade project.



## 6.0 REFERENCES CITED

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U.S. Department of Energy. Radionuclide Air Emissions Annual Report for Calendar Year 1995. June, 1996.

U.S. Environmental Protection Agency, Office of Air Programs, Research Triangle Park, NC. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. January, 1972.

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**APPENDIX A**

**RADIOACTIVE MATERIALS ASSOCIATED WITH ROCKY FLATS**

*ROCKY FLATS HEALTH PHYSICS REPORT*  
***RADIOACTIVE MATERIALS***  
***ASSOCIATED WITH***  
***ROCKY FLATS***

October 31, 1995

*B. Britton*  
*Source Registry Program Administrator*  
*303/966-8452*

Reviewed for Classification/UCNI

By: \_\_\_\_\_

Date: \_\_\_\_\_

**A. RADIOACTIVE MATERIALS HANDLED IN KILOGRAM QUANTITIES**

**1. Plutonium**

Isotopic Composition of Rocky Flats Plutonium

<u>Isotope</u>	<u>Relative Weight (percent)</u>	<u>Specific Alpha Activity (Curies/gram)</u>	<u>Specific Beta Activity (Curies/gram)</u>	<u>Relative Activity (Curies/gram)<sup>a</sup></u>
Pu-238	0.01	17.01	- - -	0.00171
Pu-239	93.79	0.0622	- - -	0.05834
Pu-240	5.80	0.228	- - -	0.01322
Pu-241	0.36	- - -	103.5	0.37260
Pu-242	0.03	0.00393	- - -	1.18x10 <sup>-6</sup>
Am-241	b	3.42	- - -	- - -

<sup>a</sup> Relative activity is obtained by multiplying the percent by weight by the specific activity. The total activity for the Plutonium Isotopes is: Alpha, 0.0732 curies/gram; and Alpha plus Beta, 0.446 curies/gram.

<sup>b</sup> Am-241 is a radioactive decay product of Pu-241.

**2. Enriched Uranium**

Common Name: Oralloy  
Normal Isotopic Composition: >90% U-235

**3. Depleted Uranium**

Common Names: Tuballoy, D-38, U-238  
Normal Isotopic Composition: <0.71%, U-235

**4. Americium (Am-241)**

Am-241 is a radioactive decay product of Pu-241.

**5. Natural Uranium (Thorium and Uranium-233)**

Rocky Flats has both the capability and potential to handle these in kilogram quantities. Some of these materials have been handled in the past.

**B. RADIOACTIVE MATERIALS HANDLED IN GRAM QUANTITIES (<1Kg)**

Curium-244  
Neptunium-237  
Uranium-233  
Plutonium-238,-242

These radioisotopes may be handled at Rocky Flats primarily for research and analytical activities.

**C. RADIOISOTOPES UTILIZED AT ROCKY FLATS AS REGISTERED AND/OR MISCELLANEOUS SOURCES**

**1. Registered Sources (Twice-Yearly Leak Test and Physical Audit)**

Sealed solids >10  $\mu$ Ci  
Plated solids >1  $\mu$ Ci  
Liquids > 10<sup>-3</sup>  $\mu$ Ci

Americium	(Am-241)	Iridium	(Ir-192)
Antimony	(Sb-124)	Iron	(Fe-55)
Barium	(Ba-133)	Nickel	(Ni-63)
Cadmium	(Cd-109)	Plutonium	(Pu-238,-239,-240,-244)
Californium	(Cf-252)	Promethium	(Pm-147)
Cesium	(Cs-137)	Radium	(Ra-226)
Cobalt	(Co-57,60)	Selenium	(Se-75)
Europium	(Eu-152)	Sodium	(Na-22)
Hydrogen (Tritium)	(H-3)	Strontium	(Sr-90)
		Thorium	(Th-228)
		Uranium	(U-234,-235,-238)

## 2. Miscellaneous Sources

Sealed solids < 10  $\mu$ Ci  
 Plated solids < 1  $\mu$ Ci  
 Liquids < 10<sup>-3</sup>  $\mu$ Ci  
 Analytical stock solutions

Aluminum	(Al-26)	Lead	(Pb-210)
Americium	(Am-241,-243)	Manganese	(Mn-54)
Antimony	(Sb-125)	Mercury	(Hg-203)
Argon	(Ar-39)	Neptunium	(Np-237)
Barium	(Ba-133)	Plutonium	(Pu-236,-238,-239 -240,241,242)
Beryllium	(B-7)	Polonium	(Po-210)
Bismuth	(Bi-207,-210)	Promethium	(Pm-147)
Cadmium	(Cd-109)	Radium	(Ra-226)
Californium	(Cf-252)	Ruthenium	(Ru-106)
Carbon	(C-14)	Selenium	(Se-75)
Cesium	(Cs-137)	Silver	(Ag-110m)
Chlorine	(Cl-36)	Sodium	(Na-22)
Cobalt	(Co-57,-60)	Strontium	(Sr86-90)
Curium	(Cm-244)	Technetium	(Tc-99m)
Europium	(Eu-152)	Thallium	(Tl-204)
Holmium	(Ho-166m)	Thorium	(Th-228,-230,-232)
Hydrogen (Tritium)	(H-3)	Tin	(Sn-113)
Iodine	(I-129,-131)	Uranium	(U-232,-234,235, -236,-238)
Iron	(Fe-55)	Yttrium	(Y-88,-90)
Krypton	(Kr-85)	Zinc	(Zn-65)

D. RADIUM SOURCES HANDLED AND STORED AT ROCKY FLATS

<u>AS/RS*</u>	<u>EG&amp;G ID</u>	<u>Nuclide</u>	<u>Location</u>	<u>Original Activity (uCi)</u>
AS	2934	Ra-226	119	0.09
RS	100	Ra-226	707	6.00000
RS	138	Ra-226	776	6.00000
RS	3695	Ra-226	881	6.26
RS	866	Ra-226	881	10.95
RS	810	Ra-226	771	11.26000
RS	409	Ra-226	371	12.5
RS	196	Ra-226	771	16
RS	23	Ra-226	777	4500
RS	146	Ra-226	777	4500

- \* AS = Accountable Source
- RS = Registered Source

**APPENDIX B**

**EFFLUENT INFORMATION SYSTEM (EIS) DATA**

96_ODIS LOCATION	ODIS LOCATION CODE	N	Effluent Volume (m <sup>3</sup> )	1996-Release (Ci)						Be (Grams)
				Pu-238	Pu-239	Am-241	U-233+4	U-238	H-3	
707-101	AFGHB707005	11	9.836E+06	6.229E-11	1.769E-10	6.726E-11	-3.895E-10	-3.964E-10		0.000000
707-102	AFGHB707006	11	1.613E+07	9.611E-11	1.083E-10	2.642E-11	-1.038E-09	-1.253E-09	7.721E-02	0.000000
707-105	AFGHB707003	11	8.156E+07	1.222E-10	5.331E-10	1.824E-10	3.008E-09	2.358E-09		0.000000
707-106	AFGHB707001	11	2.234E+07	9.831E-11	1.534E-10	1.545E-10	-3.333E-10	-7.735E-10		0.000000
707-107	AFGHB707004	11	1.681E+08	3.070E-10	9.814E-10	7.956E-10	6.798E-09	5.098E-09		0.005343
707-108	AFGHB707002	11	8.362E+07	-1.412E-11	5.859E-10	2.829E-10	3.657E-09	3.463E-09		0.000000
707-R21	AFGHI707001	1	4.502E+08	6.467E-13	2.192E-09	5.313E-09	-1.382E-08	-1.004E-08		0.000000
707-R22	AFGHI707002	1	4.502E+08	-4.573E-10	7.857E-10	4.571E-09	-1.248E-08	-1.178E-08		0.000000
707-R23	AFGHI707003	1	4.502E+08	-5.795E-11	1.069E-09	4.152E-09	-1.044E-08	-1.453E-08		0.000000
707-R24	AFGHI707004	1	4.502E+08	-1.656E-10	1.844E-09	4.559E-09	-1.352E-08	-1.082E-08		0.000000
707-R25	AFGHI707005	1	4.502E+08	-4.005E-10	4.803E-10	4.957E-09	-3.108E-09	-7.699E-09		0.000000
707-R26	AFGHI707006	1	4.502E+08	-4.373E-10	1.707E-09	4.526E-09	-1.448E-08	-1.916E-08		0.000000
707-R27	AFGHI707007	1	4.502E+08	-1.951E-10	3.582E-09	4.513E-09	-1.028E-08	-8.033E-09		0.000000
707-R45	AFGHI707008	11	4.123E+08	6.179E-10	2.576E-09	2.121E-09	-2.200E-09	-3.254E-09		0.000000
707-R46	AFGHI707009	1	4.502E+08	-3.552E-10	1.379E-09	1.111E-08	-2.523E-09	-3.793E-09		0.000000
779-782	AFGHF779002	12	5.966E+08	3.802E-10	5.991E-09	2.471E-09	2.476E-08	2.641E-08	1.977E+00	0.020675
779-729	AFGHF779001	12	1.523E+08	7.308E-10	7.871E-10	1.188E-10	-3.586E-09	-3.055E-09		0.005511
776-201	AFGHE776003	12	6.659E+06	1.784E-11	5.498E-11	2.679E-11	-9.628E-11	-9.318E-11		0.000209
776-202	AFGHE776008	12	6.543E+07	3.534E-10	1.887E-09	4.783E-10	-4.557E-12	-6.212E-10		0.000000
776-204	AFGHE776005	12	1.636E+08	1.251E-10	2.372E-09	7.987E-10	6.793E-09	6.686E-09		0.006730
776-205	AFGHE776004	12	9.574E+07	1.428E-10	1.120E-09	3.578E-10	-1.148E-09	-1.499E-09	4.123E-01	0.002429
776-206	AFGHE776002	12	7.907E+07	4.990E-10	4.334E-09	3.742E-10	-3.129E-10	-1.140E-09	1.304E+00	0.000000
776-207	AFGHE776009	12	6.104E+07	2.663E-10	3.175E-10	2.897E-10	-4.093E-09	-4.411E-09		0.000000
776-250	AFGHE776001	8	4.881E+08	3.701E-09	6.854E-08	1.077E-07	-3.569E-08	-1.639E-07	1.558E+00	0.000000
776-251	AFGHE776006	1	3.318E+08	-9.977E-11	-1.271E-10	-1.051E-09	-4.759E-08	-4.721E-08	8.800E-01	0.000000
776-252	AFGHE776007	1	8.779E+07	-5.099E-11	9.794E-11	1.361E-09	-1.073E-09	-1.697E-09		0.000000
559-561	AFGHA559001	12	5.950E+08	-5.027E-11	1.736E-08	1.041E-08	3.684E-08	4.459E-08		0.000000
778-LDY	AFGHH778001	1	2.140E+08	2.690E-09	1.216E-07	9.462E-09	1.107E-07	7.152E-07		0.000000
771-MAI	AFGHC771001	12	1.987E+09	3.335E-08	6.619E-07	1.224E-07	-8.352E-09	1.753E-08		0.053346
771-CMA	AFGHC771002	1	7.055E+07	-4.084E-13	2.291E-09	2.967E-09	8.141E-10	1.131E-08		0.000000
771-CRM	AFGHC771005	1	8.580E+07	-1.603E-10	2.395E-09	4.308E-09	-1.163E-10	9.357E-09		0.000000
774-202	AFGHD774001	12	7.258E+07	-1.036E-11	6.655E-10	9.432E-10	-1.315E-09	-1.006E-09		0.000000
444-MAI	AFGHN444004	1	1.364E+09	--	--	--	-7.482E-08	-5.620E-08		0.000000
444-D05	AFGHN444003	1	1.593E+08	--	--	--	4.350E-09	3.946E-09		0.000000
447-MAI	AFGHO447001	1	7.660E+08	--	--	--	-2.509E-09	3.546E-10		0.000000
865-EEE	AFGHP865001	1	4.137E+08	--	--	--	-1.216E-08	-1.195E-08		0.000000
865-WWW	AFGHP865002	1	6.856E+08	--	--	--	-2.302E-08	8.963E-09		0.000000
886-875	AFGHS886001	12	1.204E+08	8.687E-10	9.144E-10	3.558E-10	-3.005E-09	-4.387E-09		0.000000
881-ANX	AFGHQ881002	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00		0.000000
881-MAI	AFGHQ881001	4	3.966E+09	-5.708E-09	1.307E-07	9.726E-09	8.946E-08	8.084E-07		0.000000
883-AAA	AFGHR883001	1	7.875E+08	--	--	--	-1.734E-08	-2.077E-08		0.000000
883-BBB	AFGHR883002	1	1.098E+09	--	--	--	-9.560E-09	-1.082E-08		0.000000
883-CCC	AFGHR883003	1	2.381E+08	--	--	--	9.498E-09	1.374E-08		0.000000
889-MAI	AFGHT889001	1	8.688E+07	-5.821E-12	4.355E-10	2.651E-10	8.839E-09	9.581E-09		0.000000
991-985	AFGHU991001	1	1.266E+08	4.428E-11	6.996E-10	-1.482E-10	-2.219E-08	-2.180E-08		0.000000
374-MAI	AFGHJ374001	12	3.269E+08	8.407E-10	4.258E-09	1.154E-09	7.005E-09	5.527E-09		0.009730
991-MAI	AFGHU991002	1	1.002E+08	-9.846E-12	6.302E-10	-9.630E-10	-8.158E-09	-5.803E-09		0.000000
371-NNN	AFGHC371001	24	5.593E+08	2.034E-09	4.153E-09	2.157E-09	1.786E-08	1.652E-08		0.000000
371-SSS	AFGHC371002	12	2.884E+08	6.564E-11	1.264E-09	8.272E-10	8.899E-09	9.552E-09		0.000000
374-SPD	AFGHD374002	1	8.834E+07	7.209E-11	3.489E-09	2.138E-09	-1.660E-09	1.060E-10		0.000000
RF Plant		306	2.073E+10	3.931E-08	1.056E-06	3.263E-07	-2.315E-08	1.271E-06	6.208E+00	0.1039736

**APPENDIX C**

**STACK DATA FOR POINT SOURCES**

### Stack Data for Point Sources

Building/ Location	Height <sup>a</sup> (m)	Diameter (m)	Width (m)	Length (m)	Exit Velocity (m/s)	Stack Type	Vent No.
123-001 through 004	6 .00	0 .61	--	--	f	Grouped	f
371-SSS	16 .00	--	1 .54	5 .76	3 .44	Penthouse	2
371-NO1/NO2 <sup>b</sup>	16 .00	--	1 .54	5 .76	8 .72	Penthouse	1
374-MAI	23 .77	--	1 .83	1 .37	14 .25	Penthouse	7, 8, 9
374-SPD	9 .14	0 .42	--	--	21 .35	90°	3
444-D05	3 .56	--	0 .76	0 .61	10 .78	90°	122
444-MAI	5 .90	--	2 .74	2 .44	6 .41	90°	200
447-MAI	4 .00	--	1 .83	1 .52	8 .64	90°	201
559-561	7 .00	--	1 .22	1 .22	14 .55	Gooseneck	36
707-101	11 .33	0 .36	--	--	3 .48	Gooseneck	36
707-102 <sup>c</sup>	11 .33	--	0 .91	0 .91	2 .91	Gooseneck	9, 10
707-105	11 .33	--	0 .91	0 .91	3 .15	Gooseneck	28
707-106	11 .33	--	0 .56	0 .56	2 .57	Gooseneck	55
707-107	11 .33	--	0 .91	0 .91	6 .63	Gooseneck	65
707-108	11 .33	--	0 .76	0 .76	6 .26	Gooseneck	75
707-R21A	13 .70	1 .10	--	--	f	Open	38
707-R21B	13 .70	1 .10	--	--	f	Open	39
707-R22A	13 .70	1 .10	--	--	f	Open	40
707-R22B	13 .70	1 .10	--	--	f	Open	41
707-R23A	13 .70	1 .10	--	--	f	Open	42
707-R23B	13 .70	1 .10	--	--	f	Open	43
707-R24A	13 .70	1 .10	--	--	f	Open	44
707-R24B	13 .70	1 .10	--	--	f	Open	45
707-R25A	13 .70	1 .10	--	--	f	Open	76
707-R25B	13 .70	1 .10	--	--	f	Open	77
707-R26A	13 .70	1 .10	--	--	f	Open	78
707-R26B	13 .70	1 .10	--	--	f	Open	79
707-R27A	13 .70	1 .10	--	--	f	Open	80
707-R27B	13 .70	1 .10	--	--	f	Open	81

**Stack Data for Point Sources  
(Continued)**

Building/ Location	Height <sup>a</sup> (m)	Diameter (m)	Width (m)	Length (m)	Exit Velocity (m/s)	Stack Type	Vent No.
707-R45A	13 .00	0 .84	--	--	f	Open	1
707-R45B	12 .86	0 .84	--	--	f	Open	2
707-R46A	12 .86	0 .81	--	--	f	Open	3
707-R46B	12 .86	0 .81	--	--	f	Open	4
771-CMA	7 .67	0 .61	--	--	7 .60	Gooseneck	9
771-CRM8	7 .82	0 .45	--	--	11 .54	90°	1
771-CRM10	7 .25	--	0 .61	0 .51	2 .48	90°	8
771-MAI	50 .14	3 .12	--	--	8 .72	Open	86
774-202	7 .11	--	0 .41	0 .51	10 .98	Gooseneck	4
776-201/204/250 <sup>d</sup>	12 .00	--	0 .74	6 .17	2 .41	Penthouse	24
776-202	16 .10	0 .52	--	--	5 .86	Rain Cap	17
776-205/206/207 <sup>e</sup>	12 .00	--	0 .74	6 .17	4 .86	Penthouse	32
776-251	13 .00	--	0 .81	1 .52	8 .32	Wall penetration	45
776-252	13 .20	--	0 .91	0 .56	f	90° Wall penetration	44
778-LDY	8 .00	1 .22	--	--	5 .75	Open	50
779-729	26 .82	0 .96	--	--	7 .49	Open	12
779-782	6 .70	--	0 .91	1 .45	14 .67	Gooseneck	1
790	f	f	f	f	f	f	f
865-EEE	5 .66	--	1 .12	1 .52	7 .64	90°	63,64
865-WWW	5 .30	--	1 .42	1 .42	10 .65	90°	58,59
881-MA1	12 .40	2 .44	--	--	5 .66	Open	8
881-MA2	12 .40	2 .44	--	--	11 .13	Open	7
881-MA3	12 .40	2 .44	--	--	5 .28	Open	5
881-MA4	12 .40	2 .44	--	--	4 .62	Open	6
883-AAA	7 .41	--	1 .32	2 .50	7 .53	90°	44
883-BBB	7 .07	--	1 .32	2 .50	10 .50	90°	45
883-CCC	21 .34	1 .22	--	--	6 .40	Open	34
886-875	5 .95	--	1 .22	0 .61	9 .97	Gooseneck	15

**Stack Data for Point Sources  
(Continued)**

Building/ Location	Height <sup>a</sup> (m)	Diameter (m)	Width (m)	Length (m)	Exit Velocity (m/s)	Stack Type	Vent No.
889-MAI <sup>g</sup>	9 .75	0 .76	--	--	6 .00	Open	15
991-985	6 .25	--	1 .22	0 .51	11 .90	Gooseneck	2
991-MAI	7 .21	--	1 .37	1 .52	1 .50	Gooseneck	41

- <sup>a</sup> Above grade.
- <sup>b</sup> 371-N01/N02 combined to one penthouse.
- <sup>c</sup> 707-102 has two exhaust stacks combined.
- <sup>d</sup> 776-201/204/250 combined to penthouse vent No. 24.
- <sup>e</sup> 776-205/206/207 combined to penthouse vent No. 32.
- <sup>f</sup> Data not available.
- <sup>g</sup> Building removed during 1996.

Notes:

-- = Not applicable  
m = Meters  
m/s = Meters per second

**APPENDIX D**

**METEOROLOGICAL DATA SET**

**Meteorological Data Set  
Wind Speed and Stability Class, 1996**

WIND DIRECTION*	STABILITY CLASS	Wind Speed Frequency (%)					
		1.0 to 1.8 (m/s)	1.8 to 3.3 (m/s)	3.3 to 5.4 (m/s)	5.4 to 8.5 (m/s)	8.5 to 11.0 (m/s)	>11.0 (m/s)
N	A	0.194	0.623	0.024	0.000	0.000	0.000
NNE	A	0.282	0.811	0.000	0.000	0.000	0.000
NE	A	0.219	0.799	0.000	0.000	0.000	0.000
ENE	A	0.348	0.858	0.000	0.000	0.000	0.000
E	A	0.305	1.140	0.000	0.000	0.000	0.000
ESE	A	0.288	1.081	0.000	0.000	0.000	0.000
SE	A	0.351	0.893	0.012	0.000	0.000	0.000
SSE	A	0.171	0.470	0.000	0.000	0.000	0.000
S	A	0.167	0.235	0.012	0.000	0.000	0.000
SSW	A	0.103	0.212	0.000	0.000	0.000	0.000
SW	A	0.139	0.188	0.012	0.000	0.000	0.000
WSW	A	0.110	0.141	0.012	0.000	0.000	0.000
W	A	0.083	0.106	0.000	0.000	0.000	0.000
WNW	A	0.102	0.200	0.024	0.000	0.000	0.000
NW	A	0.112	0.165	0.012	0.000	0.000	0.000
NNW	A	0.084	0.306	0.024	0.000	0.000	0.000
N	B	0.028	0.423	0.505	0.000	0.000	0.000
NNE	B	0.039	0.400	0.811	0.000	0.000	0.000
NE	B	0.038	0.200	0.529	0.000	0.000	0.000
ENE	B	0.033	0.118	0.400	0.000	0.000	0.000
E	B	0.017	0.259	0.447	0.000	0.000	0.000
ESE	B	0.031	0.282	0.529	0.000	0.000	0.000
SE	B	0.038	0.200	0.423	0.000	0.000	0.000
SSE	B	0.037	0.176	0.270	0.000	0.000	0.000
S	B	0.016	0.059	0.094	0.000	0.000	0.000
SSW	B	0.003	0.047	0.059	0.000	0.000	0.000
SW	B	0.017	0.071	0.059	0.000	0.000	0.000
WSW	B	0.030	0.071	0.094	0.012	0.000	0.000
W	B	0.042	0.059	0.176	0.000	0.000	0.000
WNW	B	0.029	0.059	0.118	0.000	0.000	0.000
NW	B	0.004	0.059	0.235	0.000	0.000	0.000
NNW	B	0.020	0.106	0.329	0.000	0.000	0.000
N	C	0.010	0.118	0.823	0.458	0.000	0.000
NNE	C	0.035	0.247	0.529	0.165	0.000	0.000
NE	C	0.021	0.094	0.353	0.106	0.000	0.000
ENE	C	0.018	0.059	0.329	0.082	0.000	0.000
E	C	0.006	0.071	0.294	0.059	0.000	0.000
ESE	C	0.035	0.106	0.470	0.047	0.000	0.000
SE	C	0.068	0.188	0.411	0.035	0.000	0.000
SSE	C	0.057	0.212	0.470	0.094	0.000	0.000
S	C	0.029	0.188	0.118	0.035	0.000	0.000
SSW	C	0.004	0.047	0.082	0.059	0.000	0.000

**Meteorological Data Set  
Wind Speed and Stability Class, 1996  
(Continued)**

WIND DIRECTION <sup>a</sup>	STABILITY CLASS	Wind Speed Frequency (%)					
		1.0 to 1.8 (m/s)	1.8 to 3.3 (m/s)	3.3 to 5.4 (m/s)	5.4 to 8.5 (m/s)	8.5 to 11.0 (m/s)	>11.0 (m/s)
SW	C	0.018	0.059	0.129	0.071	0.000	0.000
WSW	C	0.041	0.035	0.035	0.118	0.000	0.000
W	C	0.040	0.024	0.188	0.212	0.000	0.000
WNW	C	0.005	0.059	0.176	0.223	0.000	0.000
NW	C	0.026	0.153	0.223	0.129	0.000	0.000
NNW	C	0.055	0.188	0.411	0.270	0.000	0.000
N	D	0.070	0.165	0.764	1.023	0.235	0.035
NNE	D	0.148	0.259	0.811	0.670	0.153	0.000
NE	D	0.160	0.341	0.682	0.306	0.047	0.000
ENE	D	0.171	0.329	0.517	0.165	0.000	0.000
E	D	0.082	0.247	0.388	0.129	0.000	0.000
ESE	D	0.066	0.153	0.259	0.059	0.000	0.000
SE	D	0.117	0.306	0.306	0.059	0.000	0.000
SSE	D	0.171	0.376	0.623	0.388	0.024	0.024
S	D	0.167	0.364	0.905	0.658	0.118	0.047
SSW	D	0.292	0.552	0.835	0.494	0.153	0.024
SW	D	0.390	0.705	0.987	0.787	0.165	0.094
WSW	D	0.526	0.835	0.917	1.305	0.717	0.623
W	D	0.378	0.764	1.058	1.916	1.234	2.680
WNW	D	0.234	0.470	1.128	2.692	2.339	2.139
NW	D	0.136	0.270	1.634	1.540	0.576	0.200
NNW	D	0.089	0.223	1.516	1.222	0.212	0.012
N	E	0.035	0.270	0.118	0.000	0.000	0.000
NNE	E	0.047	0.141	0.212	0.012	0.000	0.000
NE	E	0.059	0.153	0.153	0.000	0.000	0.000
ENE	E	0.024	0.071	0.129	0.000	0.000	0.000
E	E	0.024	0.071	0.047	0.000	0.000	0.000
ESE	E	0.059	0.059	0.000	0.000	0.000	0.000
SE	E	0.047	0.106	0.035	0.000	0.000	0.000
SSE	E	0.012	0.188	0.118	0.012	0.000	0.000
S	E	0.047	0.341	0.435	0.106	0.000	0.000
SSW	E	0.165	0.458	0.341	0.047	0.000	0.000
SW	E	0.094	0.541	0.505	0.024	0.000	0.000
WSW	E	0.118	0.670	0.611	0.035	0.000	0.000
W	E	0.094	0.505	0.376	0.012	0.000	0.000
WNW	E	0.059	0.341	0.411	0.012	0.000	0.000
NW	E	0.012	0.235	0.517	0.035	0.000	0.000
NNW	E	0.059	0.235	0.317	0.082	0.000	0.000
N	F	0.400	0.576	0.000	0.000	0.000	0.000
NNE	F	0.336	0.411	0.000	0.000	0.000	0.000
NE	F	0.141	0.270	0.012	0.000	0.000	0.000

**APPENDIX E**

**MODEL INPUT SUMMARY**

## MODEL INPUT SUMMARY

### Input Parameters for CAP88-PC for the Radionuclide Air Emission Annual Report for Calendar Year 1996

#### FACILITY INFORMATION

Dataset date: Model supplies date and time of dataset generation from its internal clock.  
Facility: Rocky Flats Environmental Technology Site  
City: Golden  
State: Colorado  
Zip Code: 80402-0464  
Emission Year: 1996  
Source Category: Former Nuclear Weapons Facility  
Comments: Radionuclide air emissions for the 1996 Annual Air Emission Report required under 40 CFR 61, Subpart H

#### RUN INFORMATION

Run Type: Individual (Model is run to calculate dose to maximally exposed individual [MEI], not to a population.)  
Distances: Varies (Each specific distance from the source to the receptor is entered; see Tables 4-1 through 4-7.)  
Generate genetic effects? YES  
Create Dose & Risk Factor file? YES  
Create Concentration Table file? YES  
Create Chi/Q Table file? YES

#### METEOROLOGICAL DATA

Wind file to use: Varies (Use RFP96, wind file generated from on-site meteorological data for calendar year 1996 for annual run; week 1.wnd for T-3; week 2.wnd for T-4; janfeb.wnd for T-2; and sepnov.wnd for STP Phase III.)  
Annual Precipitation: Varies (See Table 4-8.)  
Annual Ambient Temperature: Varies (See Table 4-8.)  
Height of Lid: 1405 m (Value is an annual average of mixing heights formerly measured at Stapleton International Airport. Stapleton is the closest location that has historically measured mixing height.)

#### SOURCE DATA

Source Type: Area or Stack  
Number of Sources: 1  
Height: Varies (0 for area source, specific stack height is entered for stack sources; see Table 4-1.)  
Diameter (Stack sources only): Varies (Specific stack diameter is entered here; see Table 4-1.)

## MODEL INPUT SUMMARY (Cont'd.)

Area (Area sources only): Varies (Specific area of source is entered here; see Tables 4-2 through 4-7.)  
Plume Rise: Momentum  
Exit Velocity: Varies (0 for area source, specific exit velocity is entered for stack sources; see Table 4-1.)

### AGRICULTURAL DATA

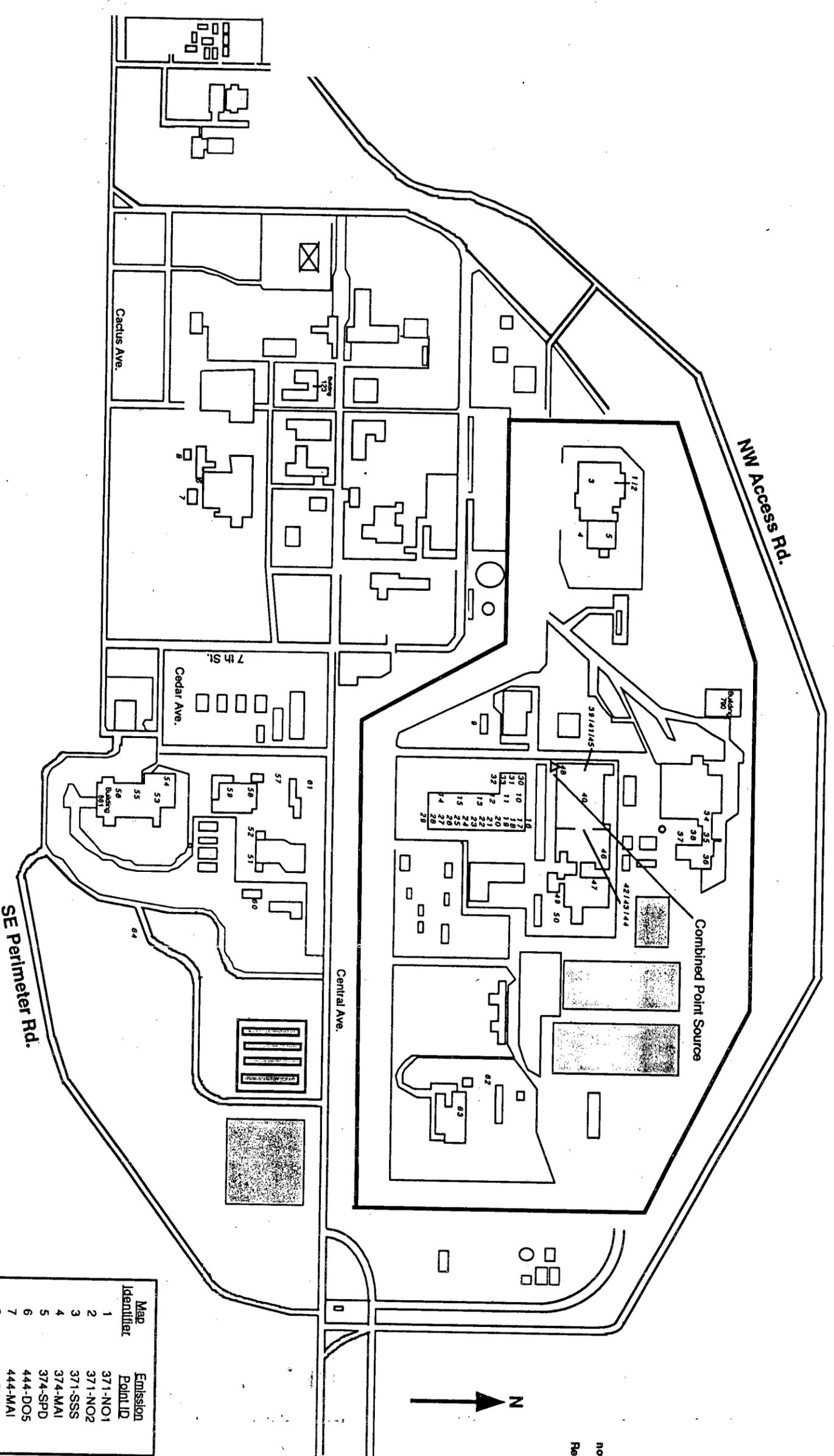
Source: Urban (The rest of the values used on this screen are defaults.)

### RADIONUCLIDE LIST

Nuclide: Varies (Radionuclide used corresponds to the source and isotope being modeled.)  
Ci/y: Varies (Release rate corresponds to the source being modeled; see Tables 3-1 through 3-3.)

### SIZE & CLASS DATA

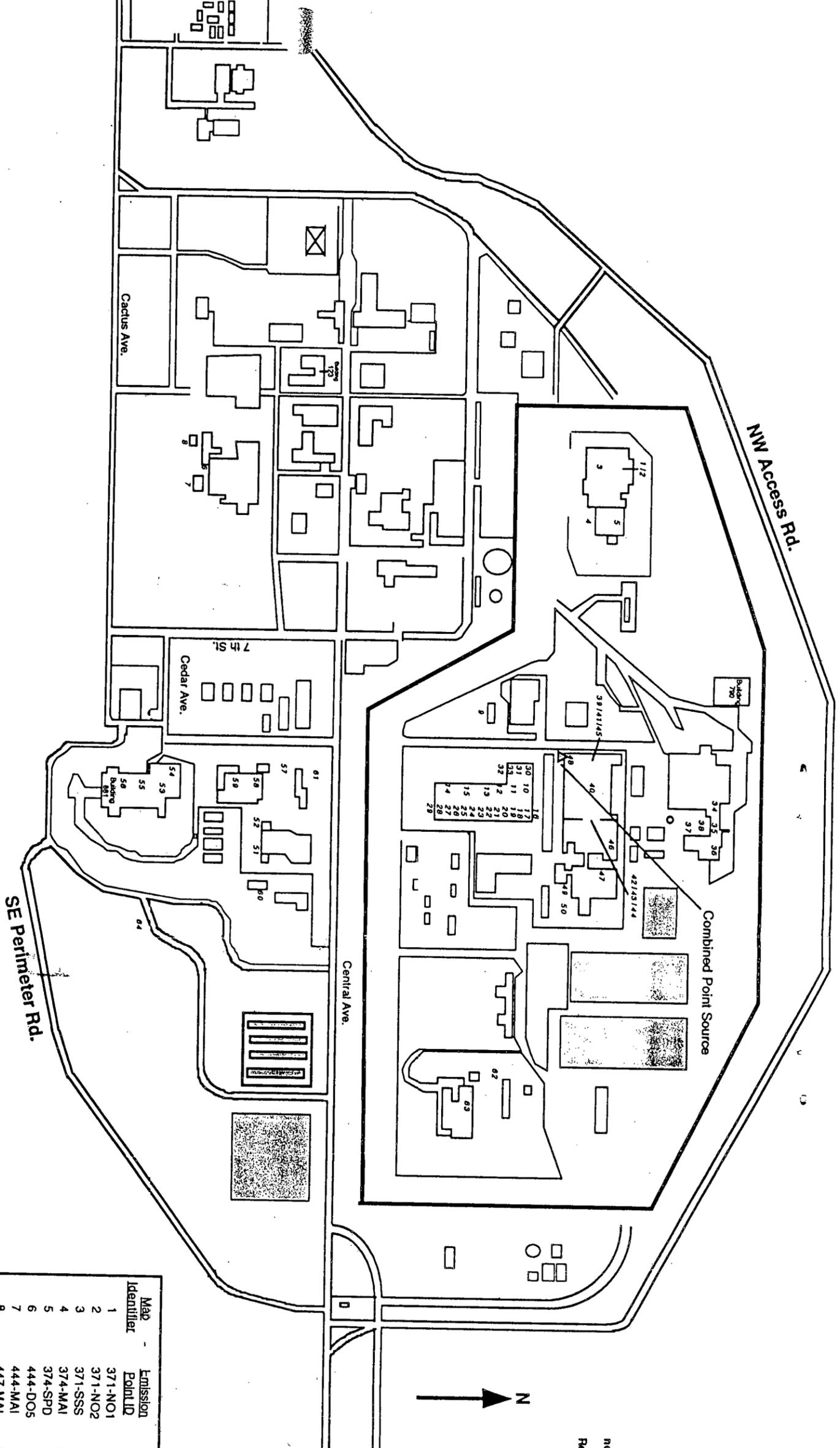
Nuclide: Varies (Radionuclide used corresponds to the source and isotope being modeled.)  
Size: Default  
Class: Default



not to scale  
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Map Identifier	Emission Point ID	Map Identifier	Emission Point ID	Map Identifier	Emission Point ID
1	371-NO1	23	707-R24B	45	776-250
2	371-NO2	24	707-R25A	46	776-251
3	371-SSS	25	707-R25B	47	776-252
4	374-MAI	26	707-R26A	48	778-LDY
5	374-SPD	27	707-R26B	49	779-729
6	444-DOS	28	707-R27A	50	779-782
7	444-MAI	29	707-R27B	51	865-EEE
8	447-MAI	30	707-R45A	52	865-WWW
9	559-561	31	707-R45B	53	881-MA1
10	707-101	32	707-R46A	54	881-MA2
11	707-102	33	707-R46B	55	881-MA3
12	707-105	34	771-CMA	56	881-MA4
13	707-106	35	771-CMA8	57	883-AAA
14	707-107	36	771-CRM10	58	883-BBB
15	707-108	37	771-MAI	59	883-CCC
16	707-R21A	38	774-202	60	886-875
17	707-R21B	39	776-201	61	889-MA1
18	707-R22A	40	776-202	62	991-985
19	707-R22B	41	776-204	63	991-MA1
20	707-R23A	42	776-205	64	C-549-1
21	707-R23B	43	776-206	65	Drum Crushing
22	707-R24A	44	776-207	66	Tank Decommissioning

Figure 4-2. Industrial Area Point Source Locations



not to scale  
Revision 1, June 1997

Figure 4-2. Industrial Area Point Source Locations

Map Identifier	Emission Point ID	Map Identifier	Emission Point ID	Map Identifier	Emission Point ID
1	371-NO1	23	707-R24B	45	776-250
2	371-NO2	24	707-R25A	46	776-251
3	371-SSS	25	707-R25B	47	776-252
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6	444-DOS	28	707-R27A	50	779-782
7	444-MAI	29	707-R27B	51	865-EEE
8	447-MAI	30	707-R45A	52	865-WWW
9	559-561	31	707-R45B	53	881-MA1
10	707-101	32	707-R46A	54	881-MA2
11	707-102	33	707-R46B	55	881-MA3
12	707-105	34	771-CMA	56	881-MA4
13	707-106	35	771-CRM8	57	883-AAA
14	707-107	36	771-CRM10	58	883-BBB
15	707-108	37	771-MAI	59	883-CCC
16	707-R21A	38	774-202	60	886-875
17	707-R21B	39	776-201	61	889-MA1
18	707-R22A	40	776-202	62	991-985
19	707-R22B	41	776-204	63	991-MA1
20	707-R23A	42	776-205	64	C-549-1
21	707-R23B	43	776-206	65	Drum Crushing
22	707-R24A	44	776-207	66	Tank Decontamination