



DOE/EIS-0161-Vol. 2

Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling

Volume II

**United States Department of Energy
Office of Reconfiguration**

October 1995

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Department of Energy

Washington, DC 20585

October 19, 1995

Dear Interested Party:

The Final Programmatic Environmental Impact Statement (PEIS) for Tritium Supply and Recycling has now been completed. Tritium is an essential component of every warhead in the current and projected United States nuclear weapons stockpile. Tritium decays at a rate of 5.5 percent per year and must be replaced periodically as long as the Nation relies on a nuclear deterrent. In accordance with the Atomic Energy Act of 1954, as amended, the Department of Energy is responsible for developing and maintaining the capability to produce nuclear materials such as tritium. Currently, the Department does not have the capability to produce tritium in the required amounts.

The Tritium Supply and Recycling PEIS evaluates the siting, construction, and operation of tritium supply technology alternatives and recycling facilities at each of five candidate sites. The PEIS also evaluates the use of a commercial reactor for producing tritium.

On October 10, 1995, the Department announced its preferred alternative, a dual-track strategy under which the Department would begin work on two promising production options: use of an existing commercial light water reactor and construction of a linear accelerator. The Savannah River Site in South Carolina has been identified as the preferred site for an accelerator, should one be constructed. Details on this preferred alternative can be found in the Executive Summary and in section 3.7 of Volume I of the PEIS. A Record of Decision will follow in late November.

The Department of Energy appreciates your continued participation in this Program.

Sincerely,

A handwritten signature in black ink, reading "Stephen M. Sohinki".

Stephen M. Sohinki, Director
Office of Reconfiguration



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Changes to the Draft PEIS that are less than a paragraph, are shown in double underline in this Final PEIS. Larger text changes are shown by sidebar notation.

COVER SHEET

RESPONSIBLE AGENCY: U.S. Department of Energy

COOPERATING AGENCY: U.S. Environmental Protection Agency

TITLE: Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling (DOE/EIS-0161).

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ABSTRACT: Tritium, a radioactive gas used in all of the Nation's nuclear weapons, has a short half-life and must be replaced periodically in order for the weapon to operate as designed. Currently, there is no capability to produce the required amounts of tritium within the Nuclear Weapons Complex.

The PEIS for Tritium Supply and Recycling evaluates the alternatives for the siting, construction, and operation of tritium supply and recycling facilities at each of five candidate sites: the Idaho National Engineering Laboratory, the Nevada Test Site, the Oak Ridge Reservation, the Pantex Plant, and the Savannah River Site. Alternatives for new tritium supply and recycling facilities consist of four different tritium supply technologies: Heavy Water Reactor, Modular High Temperature Gas-Cooled Reactor, Advanced Light Water Reactor, and Accelerator Production of Tritium. The PEIS also evaluates the impacts of the DOE purchase of an existing operating or partially completed commercial light water reactor or the DOE purchase of irradiation services contracted from commercial power reactors. Additionally, the PEIS includes an analysis of multipurpose reactors that would produce tritium, dispose of plutonium, and produce electricity.

Evaluation of impacts on land resources, site infrastructure, air quality and acoustics, water resources, geology and soils, biotic resources, cultural and paleontological resources, socioeconomic, radiological and hazardous chemical impacts during normal operation and accidents to workers and the public, waste management, and intersite transport are included in the assessment.

PUBLIC COMMENTS: In preparing the Final PEIS, DOE considered comments received by mail, fax, handed in at hearings, transcribed from messages recorded by telephone, and those transmitted via Internet. In addition, interactive public hearings were held in April 1995 at the following locations where comments and concerns identified during discussions were summarized by notetakers: Washington, DC; Las Vegas, Nevada; Oak Ridge, Tennessee; Pocatello, Idaho; North Augusta, South Carolina; and Amarillo, Texas.

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations

Acronyms and Abbreviations

APT	Accelerator Production of Tritium
ALWR	Advanced Light Water Reactor
AQCR	Air Quality Control Region
CAA	<i>Clean Air Act</i>
CEQ	Council on Environmental Quality
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act</i>
CFR	Code of Federal Regulations
CWA	<i>Clean Water Act</i>
D&D	decontamination and decommissioning
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOT	Department of Transportation
DP	DOE Office of the Assistant Secretary for Defense Programs
EA	environmental assessment
EIS	environmental impact statement
EM	DOE Office of the Assistant Secretary for Environmental Management
EPA	Environmental Protection Agency
ES&H	environment, safety, and health
HAP	hazardous air pollutants
HE	high explosive(s)
HEPA	high efficiency particulate air
HEU	highly enriched uranium
HI	Hazard Index
HLW	high-level waste
HQ	Hazard Quotient
HWR	Heavy Water Reactor
INEL	Idaho National Engineering Laboratory
IP	implementation plan
L_{eq}	equivalent sound level
LLW	low-level waste
MHTGR	Modular High Temperature Gas-Cooled Reactor
NAAQS	National Ambient Air Quality Standards
NEPA	<i>National Environmental Policy Act</i> of 1969
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory

ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Administration
PEIS	programmatic environmental impact statement
PM ₁₀	particulate matter of aerodynamic diameter less than 10 micrometers
RCRA	<i>Resource Conservation and Recovery Act</i>
ROD	Record of Decision
ROI	region-of-influence
SAR	Safety Analysis Report
SARA	<i>Superfund Amendments and Reauthorization Act</i>
SDWA	<i>Safe Drinking Water Act</i>
SHPO	State Historic Preservation Officer
SRS	Savannah River Site
START	Strategic Arms Reduction Treaty
TOC	total organic compounds
TRU	transuranic
TSCA	<i>Toxic Substances Control Act</i>
TSP	total suspended particulates
TSS	tritium supply site
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compounds
VRM	Visual Resource Management
WIPP	Waste Isolation Pilot Plant

Chemicals and Units of Measure

BGY	billion gallons per year
Btu	British thermal units
Ci	Curie
CCl ₄	carbon tetrachloride
CO	carbon monoxide
CFC	chlorofluorocarbons
dB	decibel
dBA	decibel A-weighted
DCE	1, 2-dichloroethylene
F	Fahrenheit
ft ²	square feet
ft ³	cubic feet
ft ³ /s	cubic feet per second
g	gram
gal	gallon
GPD	gallons per day
gpm	gallons per minute
GPY	gallons per year
HCFC-22	chlorodifluoromethane
HMX	cyclotetramethylenetetranitramine or 1, 3, 5, 7-tetranitro-1, 3, 5, 7-tetrazocine
hr	hour
kg	kilogram
kV	kilovolt
kVA	kilovolt-ampere
kW	kilowatt
kWh	kilowatt hour
lb	pound
lb/hr	pounds per hour
lb/yr	pounds per year
Li	lithium
mCi	millicurie (one-thousandth of a Curie)
mCi/ml	millicurie per milliliter
mg	milligram (one-thousandth of a gram)
mg/l	milligram per liter
MGD	million gallons per day
MGY	million gallons per year
mrem	millirem (one-thousandth of a rem)
MVA	megavolt-ampere
MW	megawatt
MWe	megawatt electric
MWh	megawatt hour
MWt	megawatt thermal

nCi	nanocurie (one-billionth of a Curie)
nCi/g	nanocuries per gram
NO ₂	nitrogen dioxide
NO _x	nitrogen oxides
O ₃	ozone
Pb	lead
PCB	polychlorinated biphenyl
pCi	picocurie (one-trillionth of a Curie)
pCi/l	picocuries per liter
PETN	pentaerythritoltetranitrate
ppb	parts per billion
ppm	parts per million
Pu	plutonium
RDX	cyclotrimethylenetrinitramine
rem	roentgen equivalent man
SO ₂	sulfur dioxide
TATB	triaminotrinitrobenzene
TCA	1, 1, 1-trichloroethane
TCE	trichloroethylene
TNT	trinitrotoluene
U	uranium
yd ³	cubic yards
μCi	microcurie (one-millionth of a Curie)
μCi/g	microcuries per gram
μg	microgram (one-millionth of a gram)
μg/kg	micrograms per kilogram
μg/l	micrograms per liter
μg/m ³	micrograms per cubic meter
μm	micron or micrometer (one-millionth of a meter)

Metric Conversion Chart

To Convert Into Metric			To Convert Out of Metric		
If You Know	Multiply By	To Get	If You Know	Multiply By	To Get
Length					
inches	2.54	centimeters	centimeters	0.3937	inches
feet	30.48	centimeters	centimeters	0.0328	feet
feet	0.3048	meters	meters	3.281	feet
yards	0.9144	meters	meters	1.0936	yards
miles	1.60934	kilometers	kilometers	0.6214	miles
Area					
sq. inches	6.4516	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.092903	sq. meters	sq. meters	10.7639	sq. feet
sq. yards	0.8361	sq. meters	sq. meters	1.196	sq. yards
acres	0.40469	hectares	hectares	2.471	acres
sq. miles	2.58999	sq. kilometers	sq. kilometers	0.3861	sq. miles
Volume					
fluid ounces	29.574	milliliters	milliliters	0.0338	fluid ounces
gallons	3.7854	liters	liters	0.26417	gallons
cubic feet	0.028317	cubic meters	cubic meters	35.315	cubic feet
cubic yards	0.76455	cubic meters	cubic meters	1.308	cubic yards
Weight					
ounces	28.3495	grams	grams	0.03527	ounces
pounds	0.4536	kilograms	kilograms	2.2034	pounds
short tons	0.90718	metric tons	metric tons	1.1023	short tons
Temperature					
Fahrenheit	Subtract 32 then multiply by 5/9ths	Celsius	Celsius	Multiply by 9/5ths, then add 32	Fahrenheit

Metric Prefixes

Prefix	Symbol	Multiplication Factor
exa-	E	1 000 000 000 000 000 000 = 10^{18}
peta-	P	1 000 000 000 000 000 = 10^{15}
tera-	T	1 000 000 000 000 = 10^{12}
giga-	G	1 000 000 000 = 10^9
mega-	M	1 000 000 = 10^6
kilo-	k	1 000 = 10^3
hecto-	h	100 = 10^2
deka-	da	10 = 10^1
deci-	d	0.1 = 10^{-1}
centi-	c	0.01 = 10^{-2}
milli-	m	0.001 = 10^{-3}
micro-	μ	0.000 001 = 10^{-6}
nano-	n	0.000 000 001 = 10^{-9}
pico-	p	0.000 000 000 001 = 10^{-12}
femto-	f	0.000 000 000 000 001 = 10^{-15}
atto-	a	0.000 000 000 000 000 001 = 10^{-18}

APPENDIX A

Appendix A

APPENDIX A: NUCLEAR FACILITIES

The Nuclear Weapons Complex (Complex) is comprised of facilities located at 11 major U.S. Department of Energy (DOE) sites, distributed over 10 states. Summary descriptions of the Complex sites considered for tritium supply and recycling are presented in chapters 1, 3, and 4. This appendix examines in more detail four Complex sites and one other, the Idaho National Engineering Laboratory (INEL), which is being considered as a potential addition to the Complex.

The five DOE sites include INEL, the Nevada Test Site (NTS), the Oak Ridge Reservation (ORR), the Pantex Plant (Pantex), and the Savannah River Site (SRS). The first section of this appendix provides detailed reference operation assumptions for each site examined in this Programmatic Environmental Impact Statement (PEIS). Information provided includes specific site location descriptions, current missions, facility operations, and environmental regulatory compliance activities associated with ongoing DOE Office of the Assistant Secretary for Defense Programs (DP), other DOE, and non-DOE programs.

The next section of this appendix is divided into two parts. First is the detailed description of the tritium supply technologies. This is followed by a detailed description of the tritium recycling facilities which could be either new collocated facilities or, in the case of SRS, upgrade modifications to existing facilities. Each description includes specific information describing missions, assumptions, functional parameters, expected capabilities, process descriptions, special process requirements, utilities, chemicals used, operational resources, transportation, and environmental regulatory setting. The final section discusses tritium supply technology options which are outside the scope of this (PEIS).

A.1 REFERENCE OPERATING ASSUMPTIONS

The reference case for the PEIS for Tritium Supply and Recycling is No Action, which was previously described in section 3.2.1. No Action allows a comparison of tritium supply alternatives for the candidate sites, not against the current nuclear

weapons facility configuration, but against the configuration as it would be expected to operate in 2010 and beyond.

No Action assumes that all nuclear sites of the current Complex would continue their current missions only with existing facilities that can comply with environment, safety, and health (ES&H) requirements, and at a level that is consistent with current DOE guidance. The basic missions assigned to the sites include the following: research, development, and testing; maintaining nuclear weapons production and testing capability; processing and storage of nuclear materials; operation of an extensive transportation safeguards system to assure the safe, secure movement of weapons and strategic quantities of nuclear materials within the continental United States; non-weapon projects; energy programs; and, cooperation with the Department of Defense (DOD) in responding to nuclear accidents or incidents throughout the world.

Under No Action, the siting and construction of a new tritium supply facility would not occur, there would be no upgrades/modifications of existing facilities, and future support of the nuclear weapons stockpile would be provided within the confines of the existing Complex capabilities. Some mission requirements for maintenance of the weapons stockpile in the future would not be met under No Action. However, No Action includes those mission requirements to represent a reference against which tritium supply and recycling alternatives that would meet the Department's *Atomic Energy Act* responsibilities could be compared.

Sites would continue waste management programs to meet the legal requirements and commitments in formal agreements and would proceed with cleanup activities. Production facilities and support roles at specific sites, however, would be downsized or eliminated in accordance with the reduced workload projected for the year 2010 and beyond.

Detailed reference descriptions of the affected nuclear sites follows. These descriptions include discussion of the site location, missions, facility operations, and environmental regulatory compliance.

A.1.1 Idaho National Engineering Laboratory

Site Description. INEL is located in 4 counties and covers 890 square miles in southeastern Idaho near Idaho Falls. The main site is 34 miles west of Idaho Falls, 38 miles northwest of Blackfoot, and 22 miles east of Arco. There is also an annex in Idaho Falls. The facility covers more than 569,000 acres with approximately 277 miles of roads, both paved and unpaved, and 30 miles of railroad tracks (figure 4.2.1-1 and table 4.2.2.2-1).

There are 450 buildings and 2,000 support structures at INEL with more than 3 million square feet (ft²) of floor space in varying conditions of utility. INEL has approximately 270,000 ft² of covered warehouse space and an additional 200,000 ft² of fenced yard space. The total area of the various machine shops is 32,665 ft². The majority of experiment sites are no longer in use and are scheduled for decontamination and decommissioning (D&D) and restoration. There are three reactors operating continuously and eight sites that formerly housed reactors, now scheduled for D&D.

Warehouses are located in all onsite areas and, on average, are filled to more than 85 percent of capacity. Also, there are 11 machine shops on the site to support all activities. Besides the main site, there is also an INEL annex in Idaho Falls which has office buildings, a computer center, and a research and development laboratory where site related technical, analytical, and administrative activities are conducted.

Four separate management and operations contractors operate the Idaho Chemical Processing Plant, the Naval Reactor Facility, Argonne National Laboratory-West, and the remainder of the site for DOE. Transportation to and from INEL is provided to all persons employed onsite. There are no long-term housing facilities at INEL. INEL procures more than \$25 million worth of material, supplies, and construction services in the region per year.

Missions. The missions of INEL are:

- Provide waste management functions.
- Perform waste processing, technology research, and development.

- Perform research on reactor safety operations, materials testing, and environmental monitoring.
- Perform breeder reactor irradiation tests.
- Perform irradiation service, geological and defense research, and develop nuclear instruments.
- Maintain a standby facility for conducting ship propulsion reactor research and training.

Facility Operations. Activities at INEL have been divided among nine distinct and geographically separate functional areas (table 3.3.2-1).

- Fuel reprocessing activities at the Idaho Chemical Processing Plant have been terminated and operations are focused on spent fuel storage and high-level waste processing.
- The Radioactive Waste Management Complex is a storage and disposal facility intended primarily for radioactive materials from defense and nuclear energy research programs. The Complex consists of three main areas: an 88-acre subsurface disposal area, a 56-acre transuranic storage area, and an administrative area.
- The Power Burst Facility supports research and development for waste reduction programs. A reactor used for thermal fuels behavior studies is now in a standby mode. Major waste reduction facilities include the Waste Engineering Development Facility, the Waste Experimental Reduction Facility, and the Mixed Waste Storage Facility.
- The Test Area North complex is the northernmost facility within INEL and consists of several experimental reactor and support facilities conducting research and development activities on reactor performance. These include the Technical Support Facility, the

Containment Test Facility, the Water Reactor Research Test Facility, and the Inertial Engine Test Facility. The Inertial Engine Test Facility has been abandoned with no future programs planned. The remaining facilities support ongoing programs that are expected to continue for the foreseeable future.

- The Auxiliary Reactor Area is the site where materials testing and environmental monitoring activities are conducted. The facilities in this area are scheduled for D&D.
- The Argonne National Laboratory-West is dedicated to breeder reactor development.
- The Test Reactor Area supports the Advanced Test Reactor which is used for irradiation testing of fuel, core materials, and instrumentation for naval reactors. Wastes from this facility are handled by the Radioactive Waste Management Complex.
- The Naval Reactors Facility is operated for DOE and U.S. Navy by Westinghouse Electric Corporation under jurisdiction of DOE's Pittsburgh Naval Reactors Office. Activities include the testing of advanced design equipment and new systems for current naval nuclear power propulsion plants and obtaining data for future design.
- The Central Facilities Area provides effective site-wide support services including transportation, shop services, health services, radiation monitoring, and administrative offices.

Defense Program Activities. There are no defense program activities currently being performed at INEL.

Other Department of Energy Activities. The Test Area North is used for light water reactor safety tests and specific manufacturing. The Naval Reactor Facility contains four reactors (being shutdown in

1995) where new designs were tested: the Submarine Prototype (S1W), the Large Ship Reactor (A1W), the Natural Circulation Submarine Prototype (S5G), and the Expended Core Facility. At the Test Reactor Area, the Advanced Test Reactor is currently operating to test reactor fuel, targets, core materials, and electronics. The Engineering Test Reactor and the Materials Test Reactor are in standby and the buildings are used for offices and test laboratories. The Auxiliary Reactor Area is being utilized for materials testing, but is scheduled for D&D in the near future. The Power Burst Facility reactor is on standby, but the area is used for low-level waste (LLW) engineering and development and for mixed waste storage. Argonne National Laboratory-West operates an Experimental Breeder Reactor for research and development. The Radioactive Waste Management Complex is used for examination and certification of INEL wastes. It also provides for storage of retrievable transuranic (TRU) waste and disposal of low-level radioactive (beta-gamma) waste. The Central Facilities Area provides support services for the entire site. There are a variety of support and service organizations onsite. These include the facilities to handle security, fire protection, facilities service and maintenance, food preparation, mail, transportation, medical, communication, warehousing, and machine shops.

Non-Department of Energy Activities. There are non-DOE activities at INEL which include research being conducted by the National Oceanic and Atmospheric Administration, the U.S. Geological Survey (USGS), and various institutions of higher learning. These activities support the designation of INEL as a National Environmental Research Park.

Environmental Regulatory Setting. The Environmental Oversight and Monitoring Agreement between DOE and the State of Idaho, signed May 21, 1990, was developed to assure the citizens of Idaho that their health and safety and the environment are being protected. This voluntary agreement addresses understandings and commitments between the parties regarding DOE's provision to the State of Idaho of technical and financial support for state activities to assess compliance with applicable laws and regulations at INEL. These activities consist of environmental oversight, monitoring, and evaluations of emergency response plans. The independent monitoring includes onsite discharges, groundwater

and air quality, and offsite radioactivity, as well as evaluation of waste minimization planning and source reduction methods. This agreement has been extended until negotiations for a new agreement, begun in 1994, are concluded.

The Department is working with Federal and state regulatory authorities to address compliance and cleanup obligations arising from its past operations at INEL. The Department is engaged in several activities to bring its operations into full regulatory compliance. These activities are set forth in negotiated agreements that contain schedules for achieving compliance with applicable requirements, and financial penalties for nonachievement of agreed upon milestones.

On December 21, 1989, the Environmental Protection Agency (EPA) placed INEL on the National Priorities List (NPL) as a "Superfund Site" pursuant to the provisions of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA). This determination was based on the contamination present due to past practices.

Air. The INEL air emission inventory, completed in March 1991, catalogs all vents and stacks at INEL. The air toxics inventory for radioactive and other hazardous air pollutants is being compiled and, when added to the air emissions inventory, will serve as the basis for the operating permits required under Title V of the *Clean Air Act (CAA) Amendments* of 1990. INEL is in full compliance with *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities* (40 CFR 61, Subpart H), with an effective dose equivalent to the public for 1991 at 0.004 millirem (mrem) per year (IN DOE 1992d:34).

The Idaho Operations Office signed a Consent Order on February 11, 1992, with the State of Idaho whereby INEL agreed to pay a monetary penalty and to apply for the appropriate air quality permit for the construction and operation of potential air pollution sources. A Notice of Violation issued in June 1991 alleged these facilities had been constructed without the required permits.

Water. The Snake River Plain aquifer, a sole source aquifer which lies beneath INEL, serves as the source for drinking water and crop irrigation in the Snake

River Basin. Natural radioactivity is found in the Snake River Plain aquifer in areas upgradient, parallel to, and distant from INEL. Onsite and offsite water samples are collected routinely to monitor the movement of waste substances, both radioactive and nonradioactive, through the aquifer onsite. Onsite drinking water samples are collected monthly from production drinking water wells in use at active site facilities. Approximately 25 percent of all drinking water samples collected in 1991, contained detectable concentrations of gross alpha activity.

The Idaho Operations Office submitted applications to the State of Idaho for two National Pollutant Discharge Elimination System (NPDES) permits in January 1992. These permit requests are for discharges of noncontact cooling water and for discharges of wastewater to the Big Lost River from the Idaho Chemical Processing Plant. No other INEL facility discharges liquid effluents to surface waters other than stormwater, and no streams or rivers flow from within INEL to locations outside the boundaries. In addition to the two NPDES permits, INEL has filed nine deep injection well permit applications with the State of Idaho. The injection wells are used to dispose of stormwater runoff. DOE continues to update the inventory of shallow injection wells.

On October 7, 1992, the Idaho Operations Office signed a Consent Order with the State of Idaho to settle the Notice of Violation issued on June 7, 1991, for alleged violation of Idaho water quality regulations. The Notice of Violation alleges that the Idaho Operations Office is subject to a state permit program for systems treating wastewater by application to the land via percolation ponds and unlined sewage systems at the Idaho Chemical Processing Plant. DOE will obtain stormwater discharge permits under NPDES. Also, draft wastewater land application permits have been issued and are currently being negotiated. INEL is currently covered under two general permits: stormwater discharges associated with industrial activity and construction activity.

Land. The *Idaho Hazardous Waste Management Act* and EPA delegation of authority to the state provides the Idaho Department of Health and Welfare authority to enforce hazardous waste management regulations and to provide oversight of *Resource Conservation and Recovery Act* (RCRA) related environmental restoration activities. INEL has

submitted the RCRA Part B permit application for treatment, storage, and disposal.

In 1989, the Governor of the State of Idaho placed a moratorium on the receipt of TRU waste from out-of-state. INEL is honoring the governor's moratorium even though solid radioactive wastes from Rocky Flats Environmental Technology Site (formerly known as the Rocky Flats Plant) have been received and buried at INEL since 1954. Offsite generators, including the Rocky Flats Environmental Technology Site and the Mound Plant, which had been approved to make routine waste shipments to the Radioactive Waste Management Complex at INEL, are adversely affected. INEL has also agreed to terminate TRU waste disposal activities on INEL. TRU waste not buried prior to this agreement is being stored at the Radioactive Waste Management Complex in compliance with applicable regulatory requirements, awaiting permanent disposal at a Federal repository.

Three areas of confirmed releases of contamination to the environment at INEL have been identified:

- The Radioactive Waste Management Complex, where small amounts of volatile organic compounds have been measured in the groundwater aquifer and trace concentrations of TRU radionuclides were detected at a 110-foot depth above the aquifer. Both contaminants are suspected to be traceable to buried TRU waste. Additional contaminants that potentially may be released include petroleum products, acids, bases, volatile organic compounds, heavy metals, radionuclides, polychlorinated biphenyls (PCBs), and asbestos.
- The Test Reactor Area, where chromium compounds have been detected beneath a wastewater pond in groundwater that is perched above the Snake River Plain aquifer. Remedial action is underway.
- The Test Area North groundwater, where volatile organic compounds were measured in wells that supply drinking water. Remedial action is underway.

DOE entered into a Federal Facility Agreement and Consent Order with EPA and the State of Idaho. The agreement, signed December 9, 1991, meets the requirement of Section 120(e) of CERCLA (42 U.S.C. § 9601 *et seq.*) for an interagency agreement with EPA for Federal agencies that have facilities included on the NPL. The Federal Facility Agreement and Consent Order is implemented by an Action Plan outlining the remedial action process, which will encompass investigation of hazardous substances and cleanup activities at INEL.

The purposes of the Federal Facility Agreement and Consent Order Action Plan are to:

- Establish a procedural framework and schedule for developing and monitoring appropriate response actions at INEL in accordance with CERCLA, RCRA, and the Idaho *Hazardous Waste Management Act*.
- Facilitate cooperation, exchange of information, and participation of the parties in such actions.
- Minimize duplication of analyses and documentation.
- Expedite the clean-up process to the maximum extent possible consistent with protection of human health and the environment.
- Supersede the existing RCRA 3008(h) Consent Order and Compliance Agreement executed on July 10, 1987.

In February 1990, INEL received a Notice of Non-compliance issued by EPA on January 29, 1990, for 28 alleged violations of RCRA regulations based on a June 5 to 9, 1989, inspection. The majority of violations have been resolved and long-term technical solutions for the Radioactive Waste Management Complex and Idaho Chemical Processing Plant have been agreed upon. On April 3, 1992, the Idaho Operations Office, the State of Idaho, and EPA Region 10 signed a Consent Order to settle the unresolved issues from the 1990 Notice of Noncompliance. The sodium in Building 703 (1,400 55-gallon drums) at the Argonne National Laboratory-West site has been

declared a waste. DOE has agreed to manage the sodium in Building 703, "...in compliance with all applicable interim status provisions of the *Hazardous Waste Management Act* and the Rules, Regulations and Standards for Hazardous Waste..." (IN DOE 1993a:124). The Consent Order sets up a schedule for corrective actions to be taken in the management of radioactive sodium bearing liquid wastes currently stored at the Idaho Chemical Processing Plant in the tanks with concrete vault secondary containment. Because the concrete vaults would react with the acidic solutions stored in the tanks, they do not meet RCRA requirements for secondary containment of hazardous wastes. The corrective actions at the Radioactive Waste Management Complex, Argonne National Laboratory-West, and the Idaho Chemical Processing Plant could take more than 25 years.

On October 7, 1992, the Idaho Operations Office signed another Consent Order with the State of Idaho to resolve the Hazardous Waste Notice of Violation issued by the state on June 5, 1991, for 23 alleged hazardous waste violations identified during the September 10 to 14, 1990, inspection. This Consent Order provides the schedule for corrective actions such as establishing satellite accumulation areas, closure of the Idaho Chemical Processing Plant percolation ponds, and discontinuing the discharge of non-RCRA wastewater into the percolation ponds prior to formal "clean" closure. Completion of these actions will resolve this Notice of Violation.

INEL generates mixed wastes that are radioactive and contain RCRA hazardous wastes banned from land disposal. The primary INEL compliance concerns for mixed wastes are the radioactive-contaminated wastes containing solvents and California-list wastes as defined in 40 CFR 268.5. These mixed wastes are subject to the RCRA land disposal restrictions which ban the land disposal of certain listed hazardous wastes unless they meet specific treatment standards. Due to the nationwide shortage of treatment and disposal facilities for these types of waste, INEL is storing these mixed wastes until better treatment and disposal options are developed. Such storage violates the Land Disposal Restrictions provisions of RCRA which permits storage only for accumulation of sufficient quantities to facilitate proper treatment, recycle, or disposal. Therefore, the Idaho Operations Office has proposed to enter into a Compliance Agreement with DOE and the State of

Idaho concerning the storage and continued generation of land disposal restriction waste until a treatment method is developed and WIPP or another suitable repository is open for disposal of mixed TRU waste. The land disposal restrictions also prohibit the storage of new restricted waste, including storage of new calcine, generated after May 1992, unless it is being accumulated to facilitate the proper treatment, disposal, or recovery, or there is an approved case-by-case extension. Because there are more than 1 million pounds of radiologically contaminated lead at INEL, serious efforts are being made to develop a lead treatment process that can satisfy the land disposal restriction.

Schedules to develop such technologies are proposed in the draft Site Treatment Plan. When finalized, the Site Treatment Plan will satisfy DOE's obligation under the *Federal Facility Compliance Act* of 1992 to develop and submit a mixed waste treatment plan for INEL.

INEL is not presently in full compliance with the *Toxic Substances Control Act* (TSCA) due to the storage of some polychlorinated biphenyl (PCB)-contaminated equipment and materials. The equipment and materials are also contaminated by various radioactive elements and treatment and disposal technology does not currently exist for these materials. DOE has an aggressive program to develop this technology but until it does, these materials must be safely stored in violation of the TSCA ban on the storage of such materials. DOE is presently negotiating a compliance agreement with the State of Idaho for the continued storage of radioactive PCB-contaminated wastes at INEL until a method for their treatment or disposal can be developed and permitted.

A.1.2 Nevada Test Site

Site Description. NTS is located in Nye County, NV, and encompasses approximately 864,000 acres. It varies in width from 28 to 35 miles (east to west) and in length from 40 to 55 miles (north to south). To the north, east, and west, the rugged, mountainous, undeveloped, Federal-owned land masses of the Nellis Air Force Range provide a buffer zone, varying from 15 to 65 miles wide, between the test areas and public lands. The Bureau of Land Management manages the land which borders the southern

and southwestern boundaries. United States Highway 95 and the town of Amargosa Valley are also to the south. The southeast corner of NTS is about 65 miles northwest of Las Vegas.

NTS is unique in that it is a large open area for which access is tightly controlled, with adequate infrastructure, to handle and run tests with hazardous or radioactive materials. Approximately 25 percent of NTS is currently undeveloped or provides buffer zones for on-going programs and projects. Facility expansions are possible within all areas and encroachment from land development is not a concern.

NTS is divided into numbered test areas to simplify the distribution, use, and control of resources (figure 4.3.1-1). The main entrance and the Desert Rock airstrip are at the southeast corner of the site (Area 22). Mercury base camp is adjacent in Area 23 and provides administrative operations and general support. Offices for DOE, DOD, Defense Nuclear Agency, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Sandia National Laboratories, New Mexico, and all of the supporting contractors of these organizations are located in this area. Dormitory, cafeteria, recreation, and transportation facilities are located here.

North of Mercury is Frenchman Flat (Area 5), an area historic for its atmospheric nuclear tests. Just north of Frenchman Flat is Area 6. The Control Point One facility which provides control over and execution of nuclear detonations at NTS is located here as is a new work-camp for construction and craft support. A shallow, usually dry, lake bed, Yucca Lake, is also in this area. Further north is the broad valley of Yucca Flat, site of much of the more recent nuclear testing (Areas 1, 2, 3, 4, 7, 9, and 10). At the northern edge of this flat at the base of Rainier Mesa, is the center of DOD/Defense Nuclear Agency activities (Area 12). The Area 12 Camp has logistic, service, and administration facilities, which, in busier times, supported the northern part of NTS but which has now been closed and consolidated with the Mercury and Area 6 camps. The Area 12 Camp provided ready access to the Defense Nuclear Agency tunnels mined into the face of Rainier Mesa. In the northwest section of NTS is Pahute Mesa. Its geology, combined with the greater distance from Las Vegas, allows its use for testing nuclear devices with larger yields (Areas 19 and 20).

Due to its large size, the perimeter of NTS is not fenced. However, roving security guards patrol the test site. Security and hazardous areas are fenced and some are protected with armed guards and electronic security measures. Capital assets at NTS include about 1,200 buildings with 8,000 units of installed equipment, approximately 300 miles of primary and secondary surfaced roads, and 400 miles of unsurfaced roads.

The NTS water system consists of 15 wells, pumps, booster pumps, and many sumps, reservoirs, chlorinator water softeners, and 100 miles of supply and distribution lines. This water system has an average weekly production of 8.5 million gallons. Total well capacity is 5,752 gallons per minute (gpm). Twelve wells supply water for domestic use on NTS. Mercury basecamp is supplied by 3 wells: 2 in Area 5 and 1 near Desert Rock Airstrip.

Electrical power to NTS is supplied by Nevada Power Company and Valley Electric Association transmission lines. Both transmission lines are rated at 138 kilovolt (kV). The Nevada Power Company line is approximately 60 miles long and ties into the NTS transmission system near Mercury. The Valley Electric Association line is more than 100 miles long. It runs from the Amargosa Valley substation and ties into the NTS transmission system at Jackass Flats substation. This system (the Nevada Power Company/Valley Electric Association transmission lines) is capable of providing 45 megawatt electric (MWe) based on a single contingency failure. NTS has over 700 miles of overhead and underground transmission and distribution power lines. NTS also uses a small amount of fuel oil. Table 4.3.2.2-1 shows the annual usage of resources.

Missions. The missions of NTS include:

- Provide the capability to conduct underground nuclear weapons tests.
- Provide technology, facilities and expertise for non-DOE customers.
- Support site characterization of Yucca Mountain.
- Conduct environmental assessment and remediation.

- Provide the DOE response for radiological or malevolent nuclear emergencies.
- Dispose of low-level radioactive waste for DOE.
- Conduct onsite and offsite technical monitoring for nuclear treaty compliance.

Facility Operations. In December 1950, President Truman established the Nevada Proving Grounds (forerunner to NTS) as the Nation's on-continent nuclear weapons testing area. The first nuclear test at NTS occurred on January 27, 1951. At that time, the nuclear weapons program was administered by the Atomic Energy Commission Albuquerque Operations Office. Atomic Energy Commission employees were sent to the Nevada Proving Grounds for the duration of a test series and then returned to Albuquerque. As tests became more frequent during the 1960's, Atomic Energy Commission created the Las Vegas-based Nevada Operations Office, which officially opened on March 6, 1962, and has administered NTS operations since then. Approximately 40 percent of the total Nevada Operations Office budget for fiscal year 1992 was for defense programs activities.

NTS is operated by four major management and operations contractors. Contractor employment levels at the test site are dependent upon programmatic requirements and have varied greatly during the history of the site. During 1988, the peak year, roughly 11,000 contractor employees were assigned to Nevada Operations Office administered activities at NTS and miscellaneous other locations, including metropolitan Las Vegas and North Las Vegas, Nevada. From that peak employment level, and particularly in view of the test moratorium that was first implemented in the fall of 1992, contractor employment levels decreased to approximately 7,700 in 1992 and further to approximately 6,850 in 1994.

The majority of the facilities at NTS were constructed 25 to 30 years ago as temporary structures; less than ten percent have been constructed in the past 15 years. Many of the facilities are also currently inadequate in one or more of the structural, mechanical, or electrical categories. Although Mercury basecamp has close to 100 percent occupancy and some forward areas are at 80 percent occupancy levels, fiscal pressures are forcing the

closure of the forward area facilities and consolidation at the Mercury basecamp. Consequently, most of the Mercury facilities are occupied with little reserve capacity.

Desert Rock Air Strip is located southwest of Mercury. The airstrip has in busier times provided scheduled air service by DOE aircraft between NTS and Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories, New Mexico, for access by researchers and testing personnel. Currently it is used only for high priority shipments.

Only one major new facility, the Device Assembly Facility, is currently under construction. However, modification of existing facilities on an as needed basis, is an ongoing activity. Drilled holes for groundwater monitoring are always in the process of being selected, designed, and developed. A waste management facility is being considered for handling TRU waste from DOE facilities; this is the only major non-defense program facility anticipated for NTS.

Defense Program Activities. Historically, most of the work carried out onsite has been related to defense program activities. Since it was established in December 1950, NTS has been the primary testing location for the Nation's nuclear explosives program. As of September 30, 1992, the United States had conducted 1,054 nuclear tests, 928 which were on the NTS and 828 of which were underground. A breakdown of the categories of the 928 nuclear tests conducted within the boundaries of the NTS from 1951, through 1992, is as follows:

- 100 atmospheric tests, 16 of which were safety tests that by design produced little or no nuclear yields.
- 10 cratering tests (i.e., shallow burial of a nuclear device).
- 9 tests in unstemmed holes to minimize, but not eliminate, the release of radioactivity to the atmosphere.
- 742 underground tests in drilled or mined shafts.
- 67 tunnel tests.

In typical defense program weapons development tests during the past several decades, a nuclear device was emplaced in a vertical drilled hole (86 to 190 inches in diameter) at depths of from 1,200 feet to 2,500 feet in the Yucca Flat basin or at Pahute Mesa. The nuclear device was assembled into the desired testing configuration and mated with a diagnostic equipment canister at NTS. Operational tests were performed repeatedly, both before and after the nuclear device was placed "down-hole," to ensure proper functioning of the telemetry. After the test package, up to 200 feet in length, was lowered to its proper depth, the vertical emplacement hole was backfilled with different materials in order to contain the resulting radioactive debris when the nuclear device was exploded. After detonation, sample recovery holes were bored into the test cavity to obtain samples of the nuclear debris for subsequent radiochemical analysis by the weapons design laboratory that furnished the nuclear device.

Underground testing was controlled at the Area 6 Control Point One. This facility contains the technical, managerial, and safety infrastructure to control the site.

As has previously been noted, since the *U.S. Nuclear Testing Moratorium Act* went into effect in early October 1992, no nuclear tests have been conducted by the United States. On the day immediately following China's October 4, 1993, nuclear test, President Clinton issued a directive to DOE to continue to maintain indefinitely a state of readiness for possible resumption of U.S. testing.

The Device Assembly Facility is the only new major facility for defense program activities at NTS. This 100,000 ft² facility was authorized in 1984, and is under construction now. Physically, it is located just south of Control Point One. It will combine and centralize all the functions and facilities of the existing device assembly area. Once the Device Assembly Facility is operational, Lawrence Livermore National Laboratory and Los Alamos National Laboratory will be able to conduct multiple operations with high explosive(s) (HE) and nuclear devices simultaneously. All aspects of the operations will be handled in this one facility due to its multiple processing areas which include; assembly cells, assembly bays, high bays, radiographic facilities, special nuclear materials laboratories, HE staging, special nuclear

materials staging, shipping and receiving areas, and associated administrative and support areas. In addition, the facility will provide for increased overall security and permit easier entrance/exit for the workers during hazardous operations. There will be no manufacturing or machining of special nuclear materials at this facility; only the assembly/disassembly and material storage/staging functions would be handled at this facility.

The Nevada Operations Office has been delegated the lead Federal role in maintaining the capability to respond to certain kinds of national emergencies. It will provide the leadership when a Federal Radiological Monitoring and Assessment Center is established. Additionally, a team of highly trained DOE and contractor radiological specialists known as the Nuclear Emergency Search Team trains, tests equipment for search and detection, and stores equipment for rapid deployment under the auspices of the Nevada Operations Office. It can be mobilized in case of accidents involving radioactive materials or a terrorist threat involving nuclear weapons.

Other Department of Energy Activities. Although the principal activity at NTS is the underground testing of nuclear devices, DOE is also involved in a number of other activities. These activities include liquified gaseous fuels spill testing, radioactive and mixed waste disposal, and the Yucca Mountain characterization programs. NTS has also been designated a DOE National Environmental Research Park.

The Liquified Gaseous Fuels Spill Test Facility in Area 5 was completed in 1986. It was operated on a fee basis for commercial users as a basic research tool for studying the dynamics of accidental releases of hazardous materials and to evaluate the effectiveness of various foams and fire retardants in accidents involving chemicals and hazardous materials. Test facility personnel discharge a measured volume of hazardous test fluid at a controlled rate onto a surface specially prepared to meet the test requirements and record close-in and downwind meteorological data and gaseous concentration levels.

NTS is participating in a program sponsored by DOE to establish a Nevada Solar Enterprise Zone. As part of this program, a 100 megawatts (MW) solar power plant may be built at NTS. The power from this plant would support Government needs in the area with the

remainder being sold to the commercial grid. This size plant can be supported with the existing transmission lines at NTS. There is also the potential to expand the solar power capability at NTS to approximately 500 MW in the future. However, this expansion would require substantial infrastructure upgrades including new transmission lines. It is assumed in this PEIS that the first 100 MW will be in place by the 2005 No Action time frame.

NTS also operates radioactive waste disposal facilities. The Radioactive Waste Management Site, located in Area 5, accepts LLW materials which were generated in the Nation's defense programs activities. This 92-acre facility consists of trenches and pits for burial of short-lived LLW, and aboveground storage of TRU waste awaiting transfer to the Waste Isolation Pilot Plant (WIPP). Also located at the Area 5 Radioactive Waste Management Site is the Greater Confinement Disposal Facility which consists of a 10 foot diameter lined shaft 120 feet deep. This facility is used for disposal of waste not suited for shallow land burial because of potential for migration into biopathways. Nonradioactive hazardous wastes are also accumulated at the Area 5 Radioactive Waste Management Site awaiting shipment to offsite disposal facilities. In Area 3, the Bulk Waste Management Site uses surface subsidence craters (that were formed by underground nuclear tests) for the emplacement and burial of LLW in bulk form (such as debris collected from atmospheric nuclear test locations).

The Yucca Mountain Site is located at the edge of NTS. It is being considered by DOE for the disposal of spent power-reactor fuel and vitrified high-level waste (HLW), the latter resulting principally from defense program activities. The Yucca Mountain Site Characterization Project staff reports directly to DOE's Office of Civilian Radioactive Waste Management. However, because it has elements based on NTS, the Nevada Operations Office provides some administrative and operational support services to the project. Current designs for the Yucca Mountain Project reflect an electrical demand of 10 MWe; this design has been downsized from earlier estimates of 30 MWe.

Recently, NTS has been designated as a DOE National Environmental Research Park with a purpose of consolidating previous ecological reports,

filling in a significant gap in the existing DOE research park network, and providing a unique opportunity for research in the arid desert environment. This not only enables NTS scientists to link into the existing ParkNet computerized data system, but also makes the extensive accumulation of environmental research collected over the history of NTS available to students and scientists throughout the world. NTS's location in the transition zone between the Southern and Northern Basin and Range Ecological Regions, and its inclusion of vast undisturbed areas of mountain ridges, closed basins and diverse ecological communities makes it particularly valuable.

From 1959 through 1973, NTS supported a series of open-air nuclear reactor, nuclear engine, and nuclear furnace tests in Area 25 at the Nuclear Research and Development Area. Another series of tests with a nuclear ramjet engine was conducted in Area 26.

Non-Department of Energy Activities. The most significant NTS activity involving non-DOE organizations has been the Defense Nuclear Agency's nuclear testing facility. Congressional legislation (the *Hatfield Amendment*), however, limited nuclear testing to those tests that support the safety and reliability of the U.S. nuclear stockpile. This may preclude further Defense Nuclear Agency nuclear tests which are done to support research into nuclear weapons effects.

Defense Nuclear Agency nuclear tests occurred in horizontal tunnels mined beneath Rainier Mesa. The nuclear devices for these tests were designed, built, funded, controlled, and executed by DP. Defense Nuclear Agency's nuclear testing provided the data base and design information for both nuclear effects and survivability. Nuclear weapons effects were studied for all U.S. tactical and strategic weapons systems that were required to operate in a nuclear warfare environment. These tests played a major role in maintaining high confidence in the nuclear stockpile and nuclear capable weapon systems. The weapons effects tests were conducted to study a number of nuclear effects including x-ray, gamma-ray, neutron, stress (thermal, electrical, and mechanical), electromagnetic pulse, airblast, ground and water shock propagation, and temperature. These tests assessed both weapons effects and the survivability of military systems in a nuclear environment.

Area 25 has been used for a variety of purposes, including U.S. Army ballistic research using depleted uranium and transporter testing for the proposed mobile MX missile. Various military exercises and training activities are also conducted in and around Area 25.

The Desert Research Institute, EPA, the University of Utah, and the Nevada Operations Office operate the Community Radiation Monitoring Program. This program provides the community surrounding NTS with an increased understanding of its activities and the natural radiation environment.

Other activities have been, and will likely continue to be, carried out for other Federal departments and agencies. Representatives from the EPA, USGS, and National Oceanic and Atmospheric Administration are onsite to assist and monitor conditions.

Environmental Regulatory Setting. Underground and aboveground testing at NTS has resulted in contamination of surface and subsurface soils and water, and the release of some radioactive isotopes and byproducts, such as metals, into the environment. A Memorandum of Understanding between DOE and the State of Nevada covers radiological releases on NTS and the required notifications. DOE has signed a Programmatic Agreement with the State of Nevada to cover archaeological and historical preservation activities. All future activities at NTS must comply with both the Memorandum of Understanding on radiological releases and the Programmatic Agreement.

The Department is working with Federal and state regulatory authorities to address compliance and cleanup obligations arising from its past operations at NTS. The Department is engaged in several activities to bring its operations into full regulatory compliance. These activities are set forth in negotiated agreements that contain schedules for achieving compliance with applicable requirements, and financial penalties for nonachievement of agreed upon milestones. This section discusses the more important agreements and other regulatory issues that must be considered before making a decision that would affect NTS.

An Agreement in Principle with the State of Nevada was signed in October 1990, and provides DOE

funding to Nevada for oversight of ES&H activities, including the environmental restoration activities at NTS. The Agreement in Principle also provides for understanding between, and commitment of, the parties regarding DOE's provision to the state for technical and financial support in return for environmental oversight and monitoring. NTS environmental permits include 43 different State of Nevada air quality operating permits involving emissions from construction, operation of facilities, boilers, storage tanks, and open burning. Five permits for onsite drinking water systems, eight permits for hauling septage, and one consolidated permit for four sewage discharges to onsite lagoons or septic tank fields also have been issued by the State of Nevada. The RCRA Part B permit application for hazardous waste was approved by the state in 1990 as number NV3890090001.

Air. Air pollution sources at NTS formerly included aggregate production, stemming activities, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities. The air pollutant of major concern at NTS from these former activities was particulate matter which included primarily fine sands emitted during stemming and tunneling operations, and carbon particles emitted during fuel combustion. While most of these activities stopped with the cessation of underground testing, the NTS air quality operating permits still contain clauses limiting the emission of particulates. Radionuclide emissions are not a problem as no significant emissions of radioactive material from venting, ventilation, or seeps have reached the uncontrolled areas surrounding NTS since 1980.

Many of these air quality operating permits require annual reports on operating hours, production summaries, occurrences of open burning, and other similar information. For example, the Nevada Air Quality Officer must be notified of each burn no later than five days following the burn. During 1990, three open burns of explosives-contaminated debris in Area 27 were reported for this permit. Also, the Nevada Air Quality Officer must be notified by telephone at least two working days in advance of each training exercise for Class A flammables, and a written summary of each exercise must be submitted within 15 days following the exercise. During 1990, seven burns were conducted for radiological

emergency response training and ten training burns were conducted by onsite fire protection services.

Water. Effluents at NTS are primarily the result of equipment cleaning and sanitary wastes. Discharges also result from groundwater seeping into the tunnels in Rainier Mesa. Tunnels have been sealed with the exception of P-Tunnel which drains to a holding tank. There are no NPDES permits for Nevada Operations Office facilities because there are no wastewater discharges to onsite or offsite surface waters. Water monitoring at NTS was limited to sampling wastewater effluent to lagoons and ponds under a series of State of Nevada permits.

Land. NTS manages two radioactive waste management sites and one hazardous waste accumulation site. As a result of its vast area, prior aboveground testing activities, and remote location, NTS serves as a disposal site for LLW generated by onsite and offsite DOE nuclear weapons program activities and facilities. NTS also serves as an interim storage site for TRU and mixed TRU wastes from its own activities and from Lawrence Livermore National Laboratory activities, prior to eventual shipment to WIPP for final disposal. Extensive environmental surveillance is conducted on NTS to monitor the radioactive waste management program sites. NTS previously served as a disposal site for DOE-nuclear-weapons-program-generated mixed wastes received under an interim status provision granted by the State of Nevada. In May 1990, mixed waste disposal operations were discontinued due to EPA issuance of the RCRA land disposal restrictions for the Third Thirds wastes. Active mixed waste disposal operations at the NTS will not commence until issuance of a State of Nevada RCRA Part B permit.

The State of Nevada has been delegated authorization to enforce RCRA by EPA. The Nevada Division of Environmental Protection provides RCRA overview of NTS. The RCRA Part B permit application, submitted in 1990, for disposal of hazardous waste and storage of mixed waste, was approved in April 1995 for storage. Activities continue to permit additional mixed waste management facilities.

The Hazardous Waste Accumulation Site consists of an impervious concrete pad with 6-inch curbs to contain spillage and runoff and a roof to protect the wastes from rain. This site is used to collect nonra-

dioactive hazardous wastes from satellite accumulation areas prior to shipping offsite to a RCRA-permitted commercial hazardous waste disposal facility.

On August 10, 1992, the state notified the Nevada Operations Office of its opinion that the uranium oxide material called Cotter Concentrate stored at NTS is probably a waste that has not yet been declared a waste. The state has requested chemical and physical data regarding the material and, if known to contain RCRA constituents or is uncharacterized, justification should be provided for continuing to classify the material as strategic material, rather than as a waste. On January 8, 1993, DOE declared that this material has no further programmatic use and that it be transferred to waste management for final disposition.

The Radioactive Waste Management Site at Area 5 is a 732-acre remote radioactive waste storage and disposal facility. Area 5 contains LLW disposal units consisting of pits and shallow trenches. It also provides the Greater Confinement Disposal Unit which consists of a 10-foot diameter shaft 120 feet deep used for experimental disposal of wastes not suited for shallow land burial because of high specific activity or a potential for migration into biopathways. Area 5 also serves as temporary storage for TRU and mixed TRU wastes on a curbed asphalt pad. Approximately 800 cubic yards (yd³) of TRU waste are stored in 55-gallon drums on pallets and in various assorted steel boxes pending shipment to WIPP.

DOE and the State of Nevada signed a Settlement Agreement on June 23, 1992, regarding alleged violations of storage of mixed TRU waste at NTS. Currently, the Nevada Operations Office plans to retain the existing inventory of mixed TRU waste pending acceptance of the waste at WIPP. The storage will likely remain under the Settlement Agreement until WIPP opens. This agreement resolves an alleged violation issued on November 1, 1990, by Nevada Division of Environmental Protection as a result of an August 1990, inspection alleging storage of mixed waste without a permit and lack of proper waste characterization. The agreement also resolves a finding of alleged violation issued on June 24, 1991, alleging an increase in the design capacity of the TRU storage pad without prior state approval. The NTS Waste Analysis Plan, submitted in April 1991, as amended

by Nevada Division of Environmental Protection, outlines the characterization procedures to be used as a result of the agreement.

As a result of this Settlement Agreement DOE will:

- Limit mixed TRU waste storage at Area 5 to the current inventory of approximately 800 yd³ (150,000 gallons).
- Obtain a Nevada hazardous waste permit before additional mixed TRU wastes are to be stored at NTS.
- Document why the current inventory of mixed TRU waste cannot be removed until after WIPP becomes operational.
- Report annually on its progress in certifying that the TRU waste stored at NTS meets the WIPP Waste Acceptance Criteria.
- Operate the Area 5 TRU waste storage pad until the waste is removed in accordance with 40 CFR 265, Subpart I.
- Obtain approval for, and construct, a cover for the waste.

A Consent Decree between the State of Nevada and Reynolds Electrical & Engineering Company, Inc., was filed on August 24, 1992, regarding alleged inadequate sampling of pondcrete received from the Rocky Flats Plant (now known as the Rocky Flats Environmental Technology Site) to be disposed at NTS in the Radioactive Waste Management Site. The resolution was a monetary payment to Nevada and the submission of a schedule for development of a sampling plan for the adequate characterization of the remaining pondcrete to be disposed at NTS.

The other Radioactive Waste Management Site is the Area 3 Bulk Waste Management Facility which accepts bulk LLW that cannot be packaged for disposal at the Area 5 Radioactive Waste Management Site. Much of the waste material buried there is contaminated soil and metal remaining onsite from the atmospheric testing of nuclear weapons at NTS. The materials are deposited in two waste management units, each consisting of two subsidence craters

with the area between the craters excavated to form a large oval disposal unit.

In 1987, a DOE task force determined that underground nuclear device testing areas are subject to the provisions of CERCLA. Under CERCLA all releases of hazardous or extremely hazardous substances that exceed reportable quantities must be reported to the National Response Center. Preliminary Assessment/Site Investigation reports required by CERCLA were prepared and provided to the EPA in 1988. The contaminants of concern at NTS are the results of historic aboveground and underground testing, the disposal of incidental wastes generated in support of the testing operations, and nuclear rocket experiments. Prior to 1963, soils contaminated during the atmospheric nuclear testing were consolidated and disposed of in fill areas. Soils and equipment contaminated with radionuclides as a result of drillback or tunnel operations were also disposed of in the drill areas at NTS. The types of possible contaminants found on the surface include: radionuclides; organic compounds; metals such as beryllium, lead, and hydrocarbons; and residues from plastics, epoxy, and drilling muds used during test boring drilling and instrumentation. Soils contaminated by plutonium are also a concern. EPA will use the revised Hazard Ranking System to determine if any NTS sites are to be included on the NPL. If NTS is placed on the NPL, then DOE anticipates entering into an interagency agreement with the State of Nevada and EPA.

A.1.3 Oak Ridge Reservation

Site Description. ORR consists of approximately 34,700 acres of Federal-owned lands located directly to the west and south, but within the incorporated city limits of Oak Ridge, TN. The city of Oak Ridge and ORR are within the region known as the Great Valley of the Tennessee River, which lies between the Comburant and Southern Appalachian mountain ranges. About 10 miles to the northwest, the Comburant mountains rise to an elevation of 3,000 feet or more while the Great Smoky Mountains National Park reaches to heights over 6,600 feet some 70 miles to the southeast. The largest city in the area, Knoxville, is located approximately 30 miles to the southeast. Land use in the five-county area surrounding ORR varies from the heavily populated and highly developed urban areas around Knoxville, to

the sparsely populated areas immediately surrounding ORR. The largest single land use for each of the five counties is forestry; the second most common use is agriculture.

DOE has three primary complexes within ORR. These are the Y-12 Plant (Y-12), the K-25 Site (formerly the Oak Ridge Gaseous Diffusion Plant), and the Oak Ridge National Laboratory. Originally built in the early 1940's for large-scale production of fissionable material for the world's first nuclear weapon, they continue to be used today as research, development, and manufacturing facilities (figure 4.4.1-1 and table 4.4.2.2-1).

Y-12 is situated on 811 acres in the eastern end of ORR in an area known as Bear Creek Valley. The primary missions of Y-12 include dismantling nuclear weapon components returned from the national arsenal, maintaining nuclear production capability and stockpile support, and providing storage for special nuclear materials. Y-12 also supports other Federal agencies through a Work for Others program. In addition, a technology transfer program has been established to support the U.S. industrial base by applying Y-12 expertise to a wide range of manufacturing problems. All of the uranium parts used in building U.S. nuclear weapons were fabricated at Y-12. The plant itself consists of 494 buildings containing more than 7 million ft² of floor space.

Although the primary mission of K-25 has been to provide enriched uranium for U.S. nuclear weapons and, later, an industrial toll enrichment service by which uranium is enriched for use in power reactors around the world, the gaseous diffusion process at K-25 designed for that function was placed in permanent shutdown in 1987, because of a lack of weapons or commercial requirements. Today, K-25 serves as an operations center for environmental restoration and waste management programs. The site is also the home of DOE's Center for Environmental Technology and Center for Waste Management.

Oak Ridge National Laboratory programs focus on basic and applied research, technology development, and technology that has been designated important to DOE and the Nation. It also performs work for non-DOE sponsors when such activities complement DOE missions and address significant national or

international issues. In addition, Oak Ridge National Laboratory supplies radioactive and stable isotopes that are not available from the private sector.

The 604 buildings on ORR outside Y-12 contain more than 17 million ft² of floor space. Most of these buildings and structures are located within K-25 or Oak Ridge National Laboratory; however, several buildings and structures owned or leased by DOE are outside ORR. The onsite buildings and structures outside the major plant sites consist of the Scarboro Facility, the Central Training Facility, the Transportation Safeguards Division Maintenance Facility, and some ancillary structures. Most physical facilities used by the various plant protection and security groups are within the primary plant's fenced area; however, the target ranges are outside the fence but within the buffer zones of the main plant areas. Small-arms ranges are located on the east end of Y-12 and north of the west end of Oak Ridge National Laboratory.

The Scarboro Facility, located within ORR and south of Y-12, houses the Oak Ridge Institute for Science and Education's Medical and Health Sciences Division's Large Animal Research Program. The Central Training Facility is shared by the site security force; DOE's Transportation Safeguards Division; and other contractor and agency security personnel. This facility also consists of a small office building, an indoor firing range, classroom and storage trailers, onsite parking, fitness facilities, and numerous outdoor firing ranges. The site, located less than 1 mile southeast of K-25, currently consists of approximately 140 acres including a buffer area. The Transportation Safeguards Maintenance Facility is the former Stone & Webster warehouse, located about 1 mile east of K-25.

The offsite buildings and structures consist of the Oak Ridge Operations Office, the DOE Office of Scientific and Technical Information, the Oak Ridge Institute for Science and Education facilities, the American Museum of Science and Energy, the prime contractor's "Townsite" facilities, the National Oceanic and Atmospheric Administration's Atmospheric Turbulence and Diffusion Laboratory, and others. With the exception of the Federal Office Building and space leased from the private sector, all buildings and structures used for DOE functions are situated on DOE-owned land.

Missions. The missions of ORR include:

- Maintain capability to fabricate uranium and lithium components and parts for nuclear weapons.
- Store uranium and lithium materials and parts.
- Dismantle nuclear weapons components returned from the stockpile.
- Process uranium, some of which is subject to International Atomic Energy Agency storage requirement provisions.
- Provide support to design agencies as requested.
- Perform waste management and D&D activities at Oak Ridge National Laboratory, Y-12, and K-25.
- Operate the Oak Ridge National Laboratory to perform basic research and development in energy, health, and environment and to produce radioactive and stable isotopes not available elsewhere.
- Sponsor Oak Ridge Institute for Science and Education programs in the areas of health, environment, and energy.
- Perform projects to support other Federal programs.
- Maintain programs to transfer unique technologies developed at Oak Ridge to private industry.
- Perform meteorological and atmospheric diffusion research.

Facility Operations. The complexes at ORR are managed by a management and operations contractor, under a contract administered by the Oak Ridge Operations Office. Current missions and functions can be grouped into the following categories: defense program activities; DOE Office of the Assistant Secretary for Environmental Management

(EM) activities; other DOE activities; and non-DOE activities.

Defense Program Activities. All defense program activities at ORR are conducted within Y-12. The site supports Nuclear Weapons Production and Surveillance and Nuclear Materials Production mission assignments housed in approximately 425 buildings and utilizing some 5.4 million ft² of floor space. Y-12 also stores depleted uranium.

Another important mission of Y-12 is the processing of uranium. Uranium materials are also recovered from the fabrication process and the disassembly of retired weapons. In addition to its functions related to uranium materials, Y-12 performs precision machining and assembles components, provides fabrication support to DOE's weapon design laboratories, and produces components for design evaluation for these customers and most of the test devices used at NTS.

Other Department of Energy Activities. Other DOE activities conducted at ORR include missions and programs of K-25, Oak Ridge National Laboratory, Y-12 nondefense programs, the Oak Ridge National Environmental Research Park, the Oak Ridge Institute for Science and Education, and the American Museum of Science and Energy. K-25 contains approximately 1,700 acres and is located 6 miles northwest of Y-12. The site consists of 250 buildings with approximately 12.2 million ft² of floor space. The original mission of K-25 was to separate uranium-235 for use in atomic weapons. In December 1987, DOE permanently shut down the gaseous diffusion processes and K-25 was placed on the list of facilities slated for decontamination and decommissioning. Today, K-25 serves as the operations center for Environmental Restoration and Waste Management Programs. It is also the home of DOE's Center for Environmental Technology and Center for Waste Management. Missions and activities include technology development, technology transfer, engineering technology, uranium enrichment support, and the central functions of business management, engineering, computing and telecommunications.

The Oak Ridge National Laboratory complex consists of approximately 2,900 acres located 4 miles

southwest of Y-12. The site has approximately 240 buildings containing 2.7 million ft².

Activities at Oak Ridge National Laboratory include basic and applied research, technology development, and other technology important to DOE and the Nation. Oak Ridge National Laboratory also performs research and development for non-DOE sponsors when such activities complement DOE missions and address significant national or international issues. Missions and activities include energy production and conservation technologies, physical and life sciences, scientific and technological user facilities, environmental protection and waste management, science and technology transfer, and education.

Oak Ridge National Laboratory also designs and provides research facilities for the scientific and technical community and supplies radioactive and stable isotopes that are not available from the private sector. Major portions of ORR are used by Oak Ridge National Laboratory in their aquatic habitat, flora, fauna, and other environmental sciences research programs.

In addition to defense program activities described above, Y-12 provides processing of radioactive source materials and support for other government agencies. Some 47 buildings containing 1.5 million ft² located on Y-12 grounds are utilized by Oak Ridge National Laboratory in support of nondefense program missions. Oak Ridge National Laboratory employs some 450 people at Y-12. Also located on the Y-12 site are approximately 20 buildings containing 300,000 ft² which house the DOE construction manager, the water plant maintenance contractor for ORR, and several organizations of the Oak Ridge Operations Office. Employment in these activities include 175 in DOE and 550 in construction manager organizations.

The Oak Ridge National Environmental Research Park, established in 1980, consists of 13,590 acres on the ORR. As one of seven DOE research parks, its purpose is to provide protected land areas for research and education in the environmental sciences and to demonstrate that energy technology development is compatible with a quality environment. There are 53 active Environmental Sciences Research Sites consisting of 3,562 acres on ORR. In

addition, there are 15 inactive sites on a total of some 323 acres.

Oak Ridge Institute for Science and Education's primary missions are to provide educational and research programs in the areas of health, environment, and energy for DOE, other federal agencies, and private industry. The American Museum of Science and Energy is located at a site contiguous to the Oak Ridge Institute for Science and Education campus. The museum contains historical displays and exhibits about energy in its various forms as well as topical matter on the growth of the nuclear power industry.

Non-Department of Energy Activities. Non-DOE activities pursued at ORR include missions and programs of the National Oceanic and Atmospheric Administration which conducts meteorological and atmospheric diffusion research that is supported by both itself and DOE. This work is done at the Atmospheric Turbulence and Diffusion Laboratory and field sites on ORR. The laboratory also provides services to DOE contractors and operates the Weather Instrument Telemetry Monitoring System for DOE.

Environmental Regulatory Setting. ORR consists of three separate sites in and around the city of Oak Ridge; however, all Federal and state environmental agreements deal with ORR as a single entity. The State of Tennessee, which has regulatory authority for air, water, solid waste, hazardous waste, and mixed waste, entered into a 5-year Monitoring and Oversight Agreement with DOE on May 13, 1991, to assure Tennessee citizens that their health, safety, and environment are being protected during ORR facility operations. The Tennessee Department of Environment and Conservation is the lead state agency for implementation of this agreement in which DOE provides financial support to allow Tennessee to carry out its commitment under the Monitoring and Oversight Agreement and the Federal Facility Agreement regarding cleanup activities. In addition, ORR performs its own environmental monitoring of effluents and surveillance of the environmental media to characterize and quantify contaminants, assess radiation exposures of members of the public, demonstrate compliance with applicable standards and permit requirements, and assess the effects, if any, on the local environment. The Monitoring and

Oversight Agreement also ensures that DOE complies with all applicable laws, regulations, and orders.

The Department is working with Federal and state regulatory authorities to address compliance and cleanup obligations arising from its past operations at ORR. The Department is engaged in several activities to bring its operations into full regulatory compliance. These activities are set forth in negotiated agreements that contain schedules for achieving compliance with applicable requirements, and financial penalties for nonachievement of agreed upon milestones. This section discusses the more important agreements and other regulatory issues that must be considered before making a tritium supply decision that would affect ORR.

On December 21, 1989, EPA placed ORR on the NPL as a "Superfund Site" pursuant to the provisions of CERCLA. This determination was based on the contamination present due to past practices.

Air. Regulation of radionuclide air emissions at ORR is governed by the Federal Facility Compliance Agreement for CAA (Rad-NESHAP) signed May 26, 1992, and the Radionuclide National Emissions Standards for Hazardous Air Pollutants (NESHAP) Compliance Plan for ORR, dated April 17, 1991. The *National Emissions Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities* (40 CFR 61, Subpart H) requires sampling and reporting to demonstrate compliance with the 10 mrem per year effective dose equivalent standard. Continuous emission sampling is required for any emission point with the potential to cause a dose exceeding 0.1 mrem per year. During 1992, 65 of 81 continuously monitored stacks were judged to have the potential to emit radioactive effluents that contribute greater than 0.1 mrem per year effective dose equivalent to an offsite individual. On March 26, 1993, EPA Region IV certified that DOE had completed all of the actions required by the ORR Rad-NESHAP Federal Facility Compliance Agreement and is considered to be in compliance with the Rad-NESHAP regulations. The annual offsite dose to the maximally exposed member of the public for ORR was 1.4 mrem in 1992, well below the 40 CFR 61 standard of 10 mrem per year (OR DOE 1993a:xxxviii).

Water. A DOE water treatment facility supplies potable water to the city of Oak Ridge and other ORR facilities. The water is treated, chlorinated, and fluoridated before distribution and meets health standards. Activities are underway to reduce discharges of priority pollutants, high temperature water, and toxic agents such as chlorine to the East Fork Poplar Creek. Two dechlorination systems were installed in late 1992, at key outfalls on East Fork Poplar Creek to help control discharges of chlorine from noncontact cooling water systems and to help to eliminate chronic fish kills in the upper reaches of the creek. Additional efforts relating to reducing non-point-source pollutants to surface streams and cleaning up mercury pollution in the East Fork Poplar Creek are being planned.

NPDES permits are required for each ORR facility. Y-12 is operating at the standards of the permit which expired in May 1990, and submitted a renewal in November 1989, with an addendum submitted in January 1993. Oak Ridge National Laboratory is operating at the standards of the permit which expired in April 1991, and submitted a renewal on October 28, 1990. Oak Ridge National Laboratory submitted a request to the state for modification of its NPDES permit based on evidence that past exceedance of total suspended solids, oil, and grease limits in the past have not impacted watershed water quality. A renewed NPDES permit was issued to K-25 on October 1, 1992, that will eliminate many of the permit exceedances which occurred repeatedly under the expired permit, but were not related to discharges from K-25. The new permit requires monitoring of storm drain discharges into settling ponds and streams, not at the outlets of these streams and ponds as did the expired permit.

Personnel at Y-12 operate a sanitary collection sewer system. Sanitary wastewater is discharged to the city of Oak Ridge under an industrial pretreatment permit. A new monitoring station was completed January 16, 1993, which allows for more accurate monitoring of the sanitary sewage discharges by Y-12. In addition to the sanitary sewer system, ORR submitted individual stormwater permit applications in October 1992, for all three sites, as required by the *Clean Water Act* (CWA) and Tennessee regulations. ORR had been performing extensive sampling since June 1991, in preparation for these applications.

On January 17, 1992, Friends of the Earth, a nonprofit corporation, filed a lawsuit against DOE in Federal District Court in Knoxville, TN. The lawsuit alleges that DOE is violating the NPDES permits because discharges of certain quantities of various pollutants into tributaries of the Clinch River have exceeded the allowable discharge limits of the NPDES permits. Friends of the Earth filed a motion for summary judgement in October 1992, and DOE filed a cross-motion for denial of summary judgement in January 1993.

Land. To satisfy the requirement under Section 104 of CERCLA for an interagency agreement, DOE, EPA Region IV, and Tennessee completed a Federal Facility Agreement effective January 1, 1992. The purposes of the Federal Facility Agreement are to: establish a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions at ORR in accordance with CERCLA, RCRA, NEPA, appropriate guidance and policy, and Tennessee state law; coordinate future assessments and most of the remedial action activities planned at ORR pertaining to environmental restoration activities under CERCLA with state laws and existing corrective actions required under the RCRA permit issued to DOE for ORR effective on October 25, 1986; minimize the duplication of investigations, analytical work, and documentation; ensure the quality of data management; expedite response actions with a minimum of delay; and achieve a comprehensive remediation of the site. The Federal Facility Agreement also addresses technical standards for new and existing liquid LLW storage tank systems; conduct of remedial investigation/feasibility studies and remedial design/remedial actions in accordance with timetables for sites listed in Appendix E of the Federal Facility Agreement; setting of annual priorities; and provision of responsive guidance by regulators when requested.

ORR facilities are being operated with a combination of RCRA Part B permits and interim status regulations. The RCRA Part B permit applications have been submitted for all of the active storage and treatment units listed on the Part A permit. Some are approved and other Part B applications are still awaiting action by the State of Tennessee. ORR facilities generate hazardous wastes, and personnel operate hazardous waste treatment and storage facilities. However, there are no units actively used for

the disposal of hazardous wastes. Closure actions are complete for several previously used hazardous waste disposal units.

DOE declared a moratorium in May 1991, on the shipment of hazardous waste to non-DOE sites to prevent waste, potentially contaminated with radioactive material, from being shipped to a facility which is not licensed to handle radioactive material. Current DOE policy on No Rad Added, which resulted from the moratorium, effectively requires all RCRA hazardous waste generated at ORR (and other DOE facilities) to be managed as mixed waste until ORR Waste Management provides sufficient evidence to convince an independent review board for each offsite shipment that selected waste streams are free of radioactivity. The No Rad Added policy, therefore, restricts the ability of ORR to ship offsite RCRA hazardous waste generated at ORR facilities. (OR DOE 1993a:xxxix).

DOE and EPA signed a Federal Facility Compliance Agreement effective June 12, 1992, covering concerns related to the RCRA land disposal restrictions. This Agreement recognizes that DOE is currently storing and will continue to generate and store hazardous wastes, including mixed wastes which contain a hazardous waste component, subject to land disposal restrictions: solvent waste, California-list waste, and Third Thirds waste. The agreement requires DOE to submit for EPA review a plan for a waste minimization program at ORR that provides for segregation of hazardous wastes from mixed wastes, substitution of nonhazardous solvents for hazardous solvents where technically practicable, and the minimization of the generation of hazardous waste throughout ORR. In addition to agreeing to implement the waste minimization program, DOE agreed to submit the following additional plans to EPA for review and approval: storage of the land disposal prohibited wastes identified in the Federal Facility Compliance Agreement; the treatment method, facility, and schedule for treating the land disposal prohibited wastes with identified existing treatment; the strategy for conducting treatability studies, technology development, and prioritization of treatment method options for land disposal prohibited wastes without identified existing treatment; and the treatment method, facility, and a schedule for the completion of such treatment for wastes without identified existing treatment. This last plan is

required not later than March 1995. The RCRA-Land Disposal Restrictions Federal Facility Compliance Agreement and the information provided in the required plans would form the basis for the site-specific mixed waste treatment plan required by the *Federal Facility Compliance Act* of 1992, for DOE facilities storing mixed wastes.

The ORR underground storage tank program regulates approximately 80 tanks and includes some that are deferred or exempt from external regulation. The tanks store petroleum and hazardous substances. ORR is ahead of its schedule for upgrading and/or replacing the underground storage tanks to implement leak detection, spill and overflow protection, and corrosion protection on all regulated tanks by 1998.

ORR facilities have PCBs from past practices and continue to generate PCB-contaminated wastes. These wastes are either shipped to a commercial disposal site, or if contaminated with uranium, stored until the TSCA Incinerator at K-25, which began operations in 1990, can process the waste. Some PCB-contaminated wastes have been stored in excess of 1 year due to: specific constituents in the waste that render it unacceptable at the TSCA incinerator; the burn priority at the incinerator; or the use of other treatment methods.

TSCA requires PCB-contaminated wastes to be disposed of within 1 year of its initial placement in storage. Due to its radioactive nature, treatment and disposal technology does not exist for most of these wastes. DOE has an aggressive program to develop this technology, but until it is available, these PCB-contaminated wastes must be safely stored, although not in compliance with TSCA. On June 11, 1992, DOE formally requested negotiation of a Federal Facility Compliance Agreement with EPA that would allow development of an ORR treatment and disposal schedule for radioactive PCB-contaminated waste and storage or disposal per the Agreement.

A.1.4 Pantex Plant

Site Description. Pantex is located in the panhandle of Texas, in Carson County. It is about 17 miles northeast of downtown Amarillo and 40 miles southwest of Pampa. The plant is located on a 10,000-acre portion of the former Pantex Army

Ordnance Plant. Pantex was constructed in the first half of the 1940's by the U.S. Army for the production of conventional ordnance. At the end of World War II, the plant was deactivated and the property eventually reverted to the War Assets Administration. In 1949, the entire installation was sold to Texas Technological College (now Texas Technological University) for one dollar. The land was to be used for experimental farming, but was subject to recall under the National Security Clause. Following an extensive survey of World War II ordnance plants, Pantex was chosen in 1951, by the Atomic Energy Commission for expansion of its nuclear weapons assembly facilities. The Army Ordnance Corps reclaimed the site for the Atomic Energy Commission and contracted a civilian contractor to rehabilitate it.

Pantex consists of 425 buildings containing approximately 2,500,000 ft² of floor space. Within the 10,000 acres, approximately 2,000 acres are dedicated to active facility operations. Approximately 8,000 acres are devoted to storage, disposal, and miscellaneous activities in support of plant operations. In addition, about 5,800 acres are leased from Texas Technological University (Texas Tech) to provide a Government-controlled safety and security zone on the south side of the facility. The buffer zones are used by Texas Tech for agricultural research with some acreage leased for private farming. An additional 1,080 acres northeast of the facility provide supplemental water rights and include a playa formerly used for the disposal of treated sewage effluent. Plant acreage also contains some 47 miles of paved roads, 17 miles of railroad tracks, 67 miles of fence, and 4 playas. All the land within a 3-mile radius of the plant site is used for agricultural purposes, either farming or grazing. Approximately 2,000 people live within 5 miles of the outside boundary of Pantex. A significant population concentration occurs southwest of the Pantex facility near the Amarillo International Airport and includes the Texas State Technical Institute and the Highland Park Village. Highland Park Village consists of 500 single- and multiple-family housing units (duplexes) with an occupancy rate averaging about 90 percent. Approximately 100 students are housed in a Texas State Technical Institute student dormitory.

The main mission of Pantex is the manufacture of HE components and the assembly and disassembly of nuclear weapons. Activities in support of the mission are conducted in portions of the facility referred to as zones. The major zones are shown in figure 4.5.1-1 and Pantex baseline characteristics are summarized in table 4.6.2.2-1.

Almost 3,000 personnel support Pantex's mission. This includes area office personnel from DOE, Sandia National Laboratories, employees actively working in quality evaluation, the courier section personnel tasked with weapon transportation, and contractor employees that operate the plant. Plant operation includes direct and support manufacturing operations, management and administrative services, protective services, and maintenance and utilities. During normal operations, approximately 600 people are assigned primarily to the Zone 12 South Material Access Area. Half of these individuals routinely handle the radioactive components that are used in weapon production. The Material Access Area is a highly restricted area where special nuclear materials are staged and assembled.

Missions. Pantex missions include:

- Manufacture HE components for use in nuclear weapons.
- Assemble nuclear weapons.
- Retrofit, maintain, and repair nuclear weapons in the stockpile.
- Provide quality assurance evaluations of nuclear weapon systems.
- Assemble nuclear weapon-like devices for testing and training programs.
- Disassemble nuclear weapons for disposal or maintenance purposes.
- Dismantle nuclear weapons no longer required.
- Provide development support to weapons design agencies as requested.

- Store strategic reserve quantities of plutonium.

Facility Operations. DOE directs all operations conducted at Pantex. Current missions and functions can be grouped into broad categories of defense program and environmental management activities. No other missions or functions are expected to be added or removed except as described in section 4.5.1 under tritium supply and recycling alternatives for Pantex.

Defense Program Activities. The main missions of Pantex are the manufacture of HE components and the assembly/disassembly and maintenance of nuclear weapons. As previously stated, activities in support of the mission are conducted in portions of the facility referred to as zones. The principal operations performed at Pantex are the assembly of nuclear weapons from components received from other DOE facilities; fabrication of chemical HE components for nuclear weapons; operation of the chemical HE synthesis and characterization group; surveillance testing and disposal of chemical HE; disassembly of obsolete nuclear weapons for retirement; and maintenance, modification, repair, and nonexplosive testing of nuclear weapons components. Weapons assembly and stockpile surveillance activities involve handling significant quantities of uranium components, plutonium components, and tritium components, as well as a variety of nonradioactive toxic chemicals. Brief descriptions of all the above mission activities follow.

HE component production includes manufacturing main charge subassemblies and mock components for use in weapon test assemblies, manufacturing small HE components, producing a variety of explosive materials from chemical reactants and commercially-produced explosives, and evaluating explosive materials and components through a variety of analytical, mechanical, and explosive tests.

New production is defined as the final assembly of a new nuclear weapon to be added to the stockpile. Pantex receives weapons components and other materials from throughout the Complex. The first step in the new production process is the mating of the HE main charge subassemblies and the special nuclear materials, which takes place within an assembly cell. Assembly bays house the remainder

of the assembly process. This is where the nuclear subassembly produced in the assembly cell is built into a complete weapon. After final assembly, the items produced at Pantex are shipped either to other facilities within the DOE Complex or to military facilities by truck.

The tasks of modification, maintenance, and repair involve the disassembly of a stockpiled nuclear weapon so that one or more of the components can be repaired, replaced, or modified. After replacing the components, the weapon is reassembled and returned to the stockpile. Activities of this type can be placed into one of the following categories:

- **Major Modification**—Replacement or modification of such components as the HE charges, the firing sets, or the electrical subassemblies.
- **Limited-Life Component Exchange**—Parts that must be periodically replaced. Some systems require extensive disassembly to accomplish this task. Pantex is responsible for disassembling these weapons, replacing the limited-life component and returning the weapons to the stockpile.
- **Repairs**—Weapons that have sustained damage. An example of such repair is the replacement of mechanical or electrical parts damaged by military users in field locations.

Pantex performs many quality assurance evaluation activities on both new and stockpiled nuclear weapons. These tests involve the disassembly of a weapon, the laboratory testing of various components, and the rebuilding of the weapon for shipment back to the stockpile. Five evaluations are performed at Pantex: New Material Laboratory Testing, New Material Flight Testing, Stockpile Laboratory Testing, Stockpile Flight Testing, and Accelerated Environmental Aging and Materials Compatibility Testing. These evaluations are outlined below:

- **New Material Laboratory Testing**—Disassembly of a randomly selected newly-produced weapon before it is shipped to the stockpile. Various components are

subjected to either destructive or nondestructive tests. After testing, the weapon is rebuilt and shipped to the stockpile.

- **New Material Flight Testing**—Similar to New Material Laboratory Testing. Units are selected at random before delivery to the stockpile and may be assembled into a nonnuclear, usually nonexplosive, joint test assembly for flight testing. These assemblies are tested aboard aircraft to verify the functioning of the components under in-flight conditions. After the test flight, the unit is returned to Pantex for further examination when possible.
- **Stockpile Laboratory Testing**—Similar to the New Material Laboratory Testing, but with two major differences. First, Stockpile Laboratory Testing is performed on units randomly selected from the stockpile. Second, some weapons selected for Stockpile Laboratory Testing are not rebuilt after the test, but are disassembled and the components destructively tested to ensure that DOE has an accurate estimate of system reliability.
- **Stockpile Flight Testing**—Has characteristics of both Stockpile Laboratory Testing and New Material Flight Testing. Components from the selected stockpiled unit are assembled into a joint test assembly for in-flight testing, and undergo similar post-test examination.
- **Accelerated Environmental Aging and Materials Compatibility**—Determines the effects of aging on the integrity of weapon systems over time. These tests involve subjecting newly-produced units to an artificial aging process or to environmental stresses to determine whether or not they retain their chemical and physical properties, and to ensure that they will react in a predictable manner after an extended period of time.

Also, some testing is performed at the Gas Analysis Laboratory, which evaluates samples taken from

accelerated aging units, material compatibility tests, development activities, material certification tests, and production operations.

Nuclear weapons no longer needed in the stockpile must be disassembled and disposed of; Pantex accomplishes this in one of the following ways:

- **Quality Assurance Disposal**—Weapons selected for Stockpile Laboratory Testing that are not to be rebuilt are disposed of. After the parts selected for testing have been removed, the remaining portion of the weapon is disassembled and the parts disposed of after component testing.
- **Dismantlement Surveillance**—Units selected for disposal in this manner are completely disassembled and selected parts subjected to testing.
- **Dismantlement**—Dismantlement activities consist of the disassembly of a weapon and the disposition (i.e., staging or destruction) of the components. Limited quality testing and evaluations may be performed.

In addition to the primary efforts associated with weapons assembly/disassembly, disposal, and quality assurance, Pantex provides development support and services to the nuclear weapon design agencies and to other government entities, as requested.

Pantex contains a number of facilities that stage (i.e., temporarily store) weapon components that are destined either for the assembly cells or for shipment back to other DOE facilities. Staging procedures may involve the leak testing of staging containers, inventory procedures to verify the number and contents of containers, and unpacking and repacking to physically verify and test contents.

Assembly and disassembly activities are conducted in Zone 12. There are special nuclear materials staging areas, HE staging and production areas, and component warehouses in Zone 12. Other Zone 12 activities include electrical component testing at the Sandia Systems Test Laboratory located there, as well as administrative office functions, craft shops,

the command center, fire station, and other general support facilities such as the cafeteria and sewage treatment.

Stockpile maintenance, testing, disassembly, and disposal missions are conducted in Zones 5 and 12. Zone 4 West is used for staging of weapons and special nuclear materials and interim storage of plutonium pits. Zone 4 East is used for staging of HE and other material. Additional sources of support to the Pantex mission include warehousing and landfill operations in Zone 10, water wells and a water treatment plant in Zone 15, and a vehicle maintenance facility in Zone 16.

The HE development area in Zone 11 consists of facilities for synthesizing and characterizing new HE. HE and HE scrap are disposed of onsite at the Burning Ground. The test firing site has several reinforced concrete bunkers containing control rooms and camera areas. Experimental HE configurations are detonated on firing pads surrounded by earthen bunkers. Selected samples of HE components are detonated for quality assurance testing.

Other Department of Energy Activities. At present, no other DOE activities are pursued at Pantex.

Non-Department of Energy Activities. At present, there are no non-DOE activities pursued at Pantex.

Environmental Regulatory Setting. In 1989, the Secretary of Energy invited the host state of each DOE facility to independently determine and verify any plant operational impacts to the environment. In response to this initiative, DOE entered into an Agreement in Principle with the State of Texas to focus on waste management, emergency response, and environmental monitoring. DOE provides required information to the State of Texas, and the State conducts sampling and research activities. DOE also issued a Grant-in-Aid for hydrogeologic characterization studies at Pantex.

On September 1, 1993, the Texas legislature created the Texas Natural Resources Conservation Commission and transferred to it the responsibilities of the Texas Water Commission and merged the Texas Air Control Board into the new agency. This agency is now organized to include the Office of Water Resource Management, Office of Air Quality, and

Office of Waste Management, among others. Pantex provides office space for Commission officials who are assigned to the plant. EPA has delegated to the State of Texas regulatory authority for air and solid and hazardous waste.

The Department is working with Federal and state regulatory authorities to address compliance and cleanup obligations arising from its past operations at Pantex. The Department is engaged in several activities to bring its operations into full regulatory compliance. These activities are set forth in negotiated agreements that contain schedules for achieving compliance with applicable requirements, and financial penalties for nonachievement of agreed upon milestones. On May 31, 1994, EPA placed Pantex on the NPL as a "Superfund Site" pursuant to the provisions of CERCLA. This determination was based on the contamination present due to past practices.

Air. The emission of radionuclides from Pantex is regulated under the *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities* (40 CFR 61, Subpart H) by EPA. The standard is that level of emissions of radionuclides that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem or less. The effective dose equivalent to any member of the public from emissions of radionuclides from Pantex in 1993 was less than 1 percent of 10 mrem. To demonstrate compliance with the 40 CFR 61 standard, Pantex performed periodic confirmatory monitoring as prescribed in 40 CFR 61.93 for DOE facilities that emit less than 1 percent of the 10 mrem per year allowable limit.

The Burning Ground, where explosives, explosive components, and explosive-contaminated materials are demilitarized as required by the *Atomic Energy Act*, operates as a RCRA Interim Status Unit and under a written Grant of Authority from the Texas Natural Resources Conservation Commission. The Burning Ground is also used to thermally treat explosive waste and explosive-contaminated waste. The Texas Natural Resources Conservation Commission has indicated its desire to modify the provisions of this authority. Discussions on the terms of the proposed permit modification between the State of

Texas, DOE, and parties to the hearing process are ongoing.

Water. The city of Amarillo operates a major water supply well field immediately north and down gradient of Pantex. Pantex also receives its drinking water from the Ogallala aquifer via five groundwater wells located on the northeast corner of the plant. The water is treated onsite and tested in accordance with requirements for public drinking water systems. The domestic water supply at Pantex meets all of the national primary and secondary drinking water standards for noncommunity, nontransient public water supply systems. On December 20, 1992, Texas Natural Resources Conservation Commission representatives inspected the domestic water supply system at Pantex. The inspection revealed that the system is being operated and maintained in compliance with Texas statutes and regulations.

Onsite monitoring wells, installed in 1990 between the former chemical burn pit and the Amarillo/Pantex water supply, have not detected any contamination. Other onsite monitoring wells have detected contamination in the upper level or perched aquifer. Pantex no longer releases aqueous waste streams containing hazardous waste or hazardous waste constituents to the land surface. EPA issued DOE a RCRA Administrative Order on Consent effective December 10, 1990, requiring Pantex to conduct a RCRA Facility Investigation to identify, assess, and correct actual and potential threats to human health or the environment resulting from the release or potential release of hazardous wastes or constituents at the facility. DOE completed the RCRA facility investigation and has completed Phase I on eight work plans and Phase II on one work plan.

In response to a request by the DOE, the EPA determined that an NPDES permit was applicable to operations conducted at Pantex. HE-contaminated wastewater is filtered and treated at individual building filter systems. Most of the filtered water flows into the wastewater lagoon. Since 1980, pursuant to the Texas Water Code, the Texas Natural Resources Conservation Commission has permitted Pantex to discharge its wastewater under a no discharge wastewater permit (Permit Number 02296). No discharge permits allow wastewater discharges not going to "Waters of the State." In 1980, the state did not consider playas to be "Waters of the

State." On December 26, 1990, the DOE filed a permit application to modify its permit. The permit application was resubmitted in May 1992, at the request of the Texas Natural Resources Conservation Commission to change the permit from a no discharge to a discharge permit.

Land. Pantex is registered with the State of Texas (Texas Natural Resources Conservation Commission Solid Waste Registration Number 30459) and operates under a hazardous waste permit HW-50284 and EPA Identification Number TX4890110527. Pantex currently operates units both under its hazardous waste permit and under interim status. On April 25, 1991, the Texas Natural Resources Conservation Commission and EPA issued a permit to Pantex to store containers and tanks and to treat hazardous waste in tanks. The permit specifically excluded 17 RCRA units at the Burning Ground, but continued the interim status of those units. Pantex thermally treats explosive waste and explosive-contaminated waste at the Burning Ground. The Burning Ground operates as a RCRA Interim Status Unit and under a written Grant of Authority from the Texas Natural Resources Conservation Commission. In November 1991, the DOE formally submitted a request to the Texas Natural Resources Conservation Commission for a Class 3 Modification to add the units at the Burning Ground to the permit. Pursuant to the public notice published on October 31, 1991, interested parties requested a hearing before a hearing examiner on the permit. On May 31, 1992, the Texas Natural Resources Conservation Commission Office of Air Quality, recommended draft hazardous waste permit provisions for the Burning Ground. The Texas Natural Resources Conservation Commission, the DOE, and parties to the hearing process are continuing discussions on terms of the proposed permit modification.

Pursuant to the requirements of the *Federal Facility Compliance Act* of 1992, DOE prepared and submitted to the EPA and Texas Natural Resources Conservation Commission an inventory of all mixed waste stored at Pantex on April 23, 1993. Pantex also submitted a Conceptual Site Treatment Plan to the Texas Natural Resources Conservation Commission in October 1993, as required by the *Federal Facility Compliance Act* of 1992. The Final Site Treatment Plan is to be submitted to the State of Texas by October 1995.

One area of alleged noncompliance resulting from the Texas Natural Resources Conservation Commission RCRA inspection in July 1992, is the storage of mixed waste for a period greater than 1 year, which is prohibited by the land disposal restrictions. Pantex is addressing the issue of mixed waste storage in its Site Treatment Plan as required by the *Federal Facility Compliance Act* of 1992. The Pantex solution will be finalized in late 1995 upon acceptance by the state of the Site Treatment Plan and state agreement to a resulting Consent Order.

As of December 31, 1993, all equipment and parts used at Pantex that contained PCBs had concentrations of less than 50 parts per million (ppm); thus, most requirements of the TSCA do not apply. TSCA regulated wastes, including asbestos and materials contaminated with less than 50 ppm PCBs, are transported to permitted facilities for treatment and disposal.

A.1.5 Savannah River Site

Site Description. SRS is located 12 miles south of Aiken, SC, and approximately 16 miles southeast of Augusta, GA. The site is located on approximately 198,000 acres in portions of Aiken, Allendale, and Barnwell counties. First established in 1950, SRS has been involved for more than 40 years in tritium operations and other nuclear material production. Today the site contains 15 major production, service, research, and development areas, not all of which are in operation at this time (figure 4.6.1-1).

The developed areas of the site account for less than 5 percent of the land use and more than 99 percent of the total capital investment. There are more than 3,000 facilities at SRS, including 740 buildings, with 5.5 million ft² of floor area. SRS baseline characteristics are summarized in table 4.6.2.2-1. The following discussion pertains to the active facilities.

The K-Reactor, the last operational reactor at SRS, has been placed into cold standby status with no provision for restart, ending all reactor operations. The other four reactors (C, L, P, and R) already were in cold standby. The separations facilities of the 200-Area (the largest being the F- and H-Canyons) are located in the center of the site. This area contains approximately 17 major facilities including waste management, defense waste processing, naval fuel

materials, and tritium separations. The new Replacement Tritium Facility, is also located in the separations area. The central shops are located in the 600-Area and perform major facility construction activities, while site administration, general support, and many of the research and development facilities are located in the 700-Area.

Missions. The current missions of SRS are:

- Tritium recycling.
- Processing Pu-238 for space mission requirements.
- Processing irradiated targets and spent nuclear fuel.
- Interim plutonium storage.
- Waste management.
- Environmental monitoring and restoration.
- Research and development at the Savannah River Technology Center.

Facility Operations. SRS is conducting tritium recycling operations in support of stockpile requirements using retired limited-life components as the tritium supply source. Some plutonium remaining from the production mission is in interim storage at SRS.

Defense Program Activities. SRS conducts tritium recycling operations (tritium bottle recycling) in support of stockpile requirements. The Replacement Tritium Facility assumed this function in fiscal year 1994 operating at 30 to 35 percent capacity, using tritium from returned limited-life components. The facility will also assume some of the Nonnuclear Consolidation Plan functional transfers from the Mound Plant. These functions include as a minimum Reservoir Surveillance Operations and Gas Transfer Systems. The Replacement Tritium Facility would also be able to support new-build production requirements, assuming the tritium is available.

Subject to completion of an EIS, the separation facilities, the F- and H-Canyons, will assess acceptability

of operations for material stabilization until onsite backlogs of fuel and target elements are processed. Upon completion of material stabilization activities, these facilities will be shut down permanently.

Other Department of Energy Activities. The Savannah River Technology Center, in 700-Area and at TNX-Area provides technical support to all DOE operations at SRS. In this role it provides for continued updating and improvement of process efficiency to help reduce costs, waste generation, and radiation exposure. The new Defense Waste Processing Facility, now in the cold test phase, is designed for waste processing, and includes a vitrification plant and incinerator.

Non-Department of Energy Activities. There are several facilities and operations at SRS that deal mainly with the ecological elements of the site. These are the Savannah River Forest Station, the Savannah River Ecology Laboratory, the South Carolina Wildlife and Marine Resources Department, the Institute of Archaeology and Anthropology, and the Soil Conservation Service.

The Savannah River Forest Station is an administrative unit of the U.S. Forest Service that provides timber management, research support, soil and water protection, wildlife management, secondary road management, and fire management to DOE. The Savannah River Forest Station manages 154,000 acres, or approximately 80 percent of the site area. It has been responsible for reforestation and manages an active timber business. The improvement of the environment has seen an increase in wildlife populations. The station assists with the development and updating of site-wide land use planning and provides continual support with site layout and vegetative management. It also assists in long-term wildlife management and soil rehabilitation projects. This unit occupies buildings on 7 acres. The Senior Community Services Employment Program operated by the Department of Labor is collocated with the station. In addition, there are also offices used by those employed to harvest the timber managed by the station.

The Savannah River Ecology Laboratory is operated for DOE by the Institute of Ecology of the University of Georgia. It has established a center of ecological field research where faculty, staff, and students

perform interdisciplinary field research to provide an understanding of the impact of energy technologies on the ecosystems of the southeastern United States. This information is communicated to the scientific community, government agencies, and the general public.

The South Carolina Wildlife and Marine Resources Department manages a program to restore turkeys to their former range throughout the state. The Institute of Archaeology and Anthropology is operated by the University of South Carolina to survey the archaeological resources of the SRS. This survey is used by DOE when planning new facility additions or modifications and is referred to in the operational management of the site. A soil survey report for land use management at the site has been completed.

Environmental Regulatory Setting. The South Carolina Department of Health and Environmental Control is the state regulatory agency with authority for air, water, solid waste, mixed, and hazardous waste. DOE and South Carolina signed a Memorandum of Agreement on April 8, 1985, designed to meet both parties' interests in maintaining the environmental qualities on SRS. DOE recognizes South Carolina's delegated authority under CAA, CWA, *Safe Drinking Water Act* (SDWA), and RCRA, and agrees to abide by South Carolina environmental laws. South Carolina recognizes that SRS has unique Federal obligations regarding the Federal budget process, NEPA requirements, and classified information. Both parties agreed to a First Amendment to this Memorandum of Agreement on May 5, 1988, stating that DOE shall comply with the South Carolina Underground Storage Tank Regulation.

The Department is working with Federal and state regulatory authorities to address compliance and cleanup obligations arising from its past operations at SRS. The Department is engaged in several activities to bring its operations into full regulatory compliance. These activities are set forth in negotiated agreements that contain schedules for achieving compliance with applicable requirements, and financial penalties for nonachievement of agreed upon milestones. This section discusses the more important agreements and other regulatory issues that must be considered before making a reconfiguration decision that would affect SRS.

On December 21, 1989, EPA placed SRS on the NPL as a "Superfund Site" pursuant to the provisions of CERCLA. This determination was based on the contamination present due to past practices.

Air. SRS has 14 air quality permits covering 141 point sources for air emissions. According to EPA Region IV, the air monitoring systems at SRS do not adequately provide for monitoring of radionuclide emissions from point sources as specified by *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities* (40 CFR 61, Subpart H), effective December 15, 1989. This requirement states that emissions of radionuclides from DOE facilities shall not exceed those amounts which would cause any member of the public to receive an effective dose equivalent of 10 mrem per year. In order to determine compliance, DOE must provide for monitoring of radionuclide emissions from point sources with the potential to emit 0.1 mrem per yr. Therefore, DOE and EPA entered into the Federal Facility Compliance Agreement for Radionuclide NESHAP on October 31, 1991, allowing SRS to continue operations and at the same time upgrade facilities to come into compliance with the NESHAP monitoring requirements of 40 CFR 61, Subpart H.

Water. SRS has 76 outfalls on NPDES permit, SC0000175, which has been administratively extended since 1988. Since 1986, the compliance rate for NPDES regulated discharges has remained above 99 percent. SRS has two other NPDES permits: SC0044903 and one general stormwater discharge permit. A new combined NPDES permit is expected to be issued in 1995.

SRS has documented groundwater contamination. Concentrations of at least one of the following constituents: tritium, gross alpha or trichloroethylene (TCE) in excess of primary drinking water standards were observed in at least one monitoring well at the landfill in the first half of 1989. TCE concentrations up to 400 parts per billion (ppb) have also been detected approximately 800 feet from the SRS boundary. Quarterly status reports of its groundwater quality assessment programs for F-, H-, and M-Areas is required by Administrative Consent Order 85-70-SW dated November 7, 1985, and amended on September 14, 1988. SRS has accomplished all one-time requirements of this order and continues the

routine assessment and corrective action as required by the order.

DOE entered into a Settlement Agreement on February 27, 1990, to satisfy violations of discharging wastewater into the environment of the state without a permit. DOE began construction of a Sanitary Wastewater Treatment Plant that will handle effluent discharged from Outfall A008 of the A-Area Powerhouse and other discharges as well. Construction will be completed in 1995.

DOE entered into two settlement agreements under the CWA on June 5, 1990, agreeing to address high temperature discharges and related fish kills. The Thermal Mitigation Settlement Agreement, dated June 5, 1990, alleges failure to comply with both the thermal requirements of the NPDES permit and Consent Order 84-4-W, dated January 3, 1984, and requires DOE to address corrective actions for any outfall which exceeds 90 °F. On June 15, 1990, DOE issued the SRS Plan of Study for Minor Thermals to the state and is awaiting approval of the plan that will satisfy this agreement. The Fish Kill Settlement Agreement requires compliance with the Fish Kill Remedial Action Plan submitted by SRS on July 5, 1990, and commented on by the Department of Health and Environmental Control on October 25, 1990, to mitigate high temperature discharges from the L- and P-Reactors which may have resulted in fish kills. On December 12, 1991, South Carolina approved the SRS request to delay remedial actions at Pond C of Par Pond and at the L-Lake due to changes in status of the P-Reactor.

SRS was not able to comply fully with thermal discharge limitations contained in the NPDES permit and, therefore, conducted a Thermal Mitigation Study. The study showed a need for major construction. South Carolina issued Consent Order 84-4-W which was later amended to require construction of the K-Reactor mitigation alternative not later than December 31, 1992, and to submit a 316(a) plan of study for the D-Area coal-fired facility. The 316(a) study was submitted and is considered conditionally complete. On December 22, 1992, SRS submitted documentation to the state that the K-Reactor mitigation alternative (the cooling tower) had been completed and would allow SRS to discharge K-Reactor cooling effluent in compliance with laws and permit requirements for SRS. Completion of the

cooling tower accomplished one of the last thermal mitigation requirements in Consent Order 84-4-W. However, in March 1993, DOE placed the K-Reactor in cold standby with no provision for restart.

Land. EPA identified approximately 150 potential operable units and 20 RCRA-regulated units on SRS. In accordance with Section 120 of CERCLA, DOE entered into a Federal Facility Agreement effective August 16, 1993, with the EPA and South Carolina to coordinate cleanup activities at SRS under one comprehensive strategy. The plan also directs interim status corrective action for releases of hazardous waste or hazardous constituents. The Federal Facility Agreement expands the ongoing RCRA Facility Investigation Program Plan under RCRA Sections 3004(u) and 3004(v) to include those releases as a CERCLA cleanup which are not already included in the RCRA *Hazardous Waste Management Act* permit.

The purposes of the Federal Facility Agreement are to:

- Meet the requirements of CERCLA for an interagency agreement and assure compliance with Federal and state hazardous waste laws for matters covered by this agreement.
- Provide for state involvement in the initiation, development, selection, and enforcement of corrective/remedial actions.
- Identify operable units for investigation and possible corrective/remedial action.
- Establish requirements for the performance of investigations to determine fully the nature and extent of the threat to the public health or welfare.
- Identify the nature, objective and schedule of response actions to be taken at SRS; establish a basis for a determination that the DOE has completed the remedial actions required.
- Establish requirements for the SRS high-level radioactive waste tank system to

ensure structural integrity, containment and detection of releases.

SRS has further agreed in the Federal Facility Agreement to ensure structural integrity, containment and detection of releases, and source control for the SRS high-level radioactive waste tank systems identified in Appendix B of the agreement. SRS will also develop a process to review the risk associated with each of the regulated single-wall storage tanks on a tank-by-tank basis. This process will result in a tank removal or abandonment program which is protective of human health and the environment and which is in compliance with the provisions of RCRA (40 CFR 264, Subpart J), the agreement, and all other applicable regulations. According to the Waste Removal Plan and Schedule submitted to the state on November 15, 1993, the schedule to remove waste from the tanks that do not meet secondary containment requirements is the year 2028. Radioactive waste is contained in 23 of the underground storage tanks. Further construction of the single-wall type tank for storage of radioactive waste is prohibited by the Federal Facility Agreement. SRS must meet storage tank/container standards in 40 CFR 264 and provide a schedule for submitting complete RCRA permit applications for new facilities to come on line. Schedules have been agreed upon within the Federal Facility Agreement to provide compliance through construction of treatment facilities and other measures.

The Federal Facility Compliance Agreement signed by EPA and DOE on March 13, 1991, addresses SRS compliance with the Land Disposal Restrictions of the Hazardous and Solid Waste Amendments of 1984 pertaining to past, ongoing, and future generation of mixed wastes (mostly solvents, dioxin and California list wastes contaminated with radioactive tritium from rags and wipes used to remove radioactive-contaminated and nonradioactive solvents and wastes from equipment), that are prohibited from land disposal without treatment to standards. This Federal Facility Compliance Agreement supersedes the July 30, 1987, Federal Facility Compliance Agreement for Past Disposal at the Mixed Waste Management Facility and incorporates any remaining provisions in addition to the new requirements. In this agreement, the parties agreed that the high-level mixed waste in the tank farms must be allowed to decay to an appropriate level of radioac-

tivity before processing at the Defense Waste Processing Facility and that such aging shall be considered an accumulation of such quantities of hazardous waste as is necessary to facilitate proper treatment, recovery or disposal so long as the other requirements contained in 40 CFR 268.50 are met.

The Federal Facility Compliance Agreement allows SRS to continue to operate, generate, and store mixed wastes subject to the Land Disposal Restrictions and outlines a plan for mixed waste compliance that, when approved by South Carolina, would allow SRS to come into compliance with the mixed waste storage provisions of the *Federal Facility Compliance Act* of 1992. In return, SRS will report to EPA the characterization of all solid waste streams disposed in land disposal units at SRS, will identify within 60 days any new hazardous waste streams introduced, and will submit a plan for waste minimization to EPA for review. DOE submitted the required waste minimization plan on time. SRS is also required to segregate restricted wastes, excluding those previously located on the TRU storage pads, from other mixed wastes and report on a recurring basis the identity, quantity, and compliance problems associated with restricted mixed wastes and the impact of Land Disposal Restrictions requirements.

Under the provisions of the Federal Facility Compliance Agreement, SRS agreed to report construction and operational data and waste processing milestones for the Consolidated Incineration Facility, Defense Waste Processing Facility, and other hazardous waste storage, treatment, and disposal facilities planned to be built at SRS. This reporting is required because their use is key to long-term compliance with Land Disposal Restrictions for mixed waste. SRS is required to prepare TRU waste for shipment to WIPP, but the agreement allows continued storage of certified TRU waste at the TRU waste storage pads until its suitability has been determined pursuant to the provisions of 40 CFR 191 and 40 CFR 268 and it can be shipped to WIPP. In addition, DOE agreed to provide EPA with an annual progress report on WIPP, and this agreement must be modified if DOE determines that no TRU waste will be shipped from SRS by July 30, 1999. Finally, SRS agreed to provide hazardous waste training to EPA Region IV employees. On April 24, 1992, the agreement was amended to include Third Thirds restricted wastes and an alter-

native treatment strategy for M-Area waste. The periodic reporting requirements of the original agreement were also amended.

On September 30, 1987, the South Carolina Department of Health and Environmental Control issued the RCRA Part B Permit (RCRA SC1890008989) that granted final status to four hazardous waste storage buildings and approved a postclosure plan for the M-Area Settling Basin and vicinity. The RCRA permit requires SRS to assess and, where necessary, take appropriate corrective action for any releases of hazardous wastes. Additional hazardous waste facilities, subject to RCRA interim status when the permit was approved, have been added to the RCRA permit.

In January 1990, DOE notified the South Carolina Department of Health and Environmental Control that rags and wipes used with F-listed solvents for cleaning and for radioactive decontamination had been disposed in portions of the Low-Level Radioactive Waste Disposal Facility and in the SRS Sanitary Landfill. The Department of Health and Environmental Control advised DOE and SRS that certain solvent rags and wipes constituted hazardous waste subject to *South Carolina Hazardous Waste Management Act* regulation. As a result, DOE and South Carolina signed Settlement Agreement 91-51-SW effective August 26, 1991, to satisfy South Carolina allegations that SRS failed to comply with interim status standards for operation of the Low-Level Radioactive Waste Disposal Facility and the sanitary landfill in the disposal of spent solvent wastes without having applied for, or received, a permit for

operation of these units. SRS agreed to refrain from further disposal of F-listed solvent contaminated rags and wipes in the Low-Level Radioactive Waste Disposal Facility and sanitary landfill or any other facility not specifically permitted for such disposal.

An SRS Public Involvement Plan has been designed to facilitate public involvement in decision-making processes for permitting, closure, and selection of remedial alternatives. The plan addresses the requirements of CERCLA, RCRA, and NEPA, and forms the basis for continued involvement of stakeholders at SRS. As envisioned by the revised plan, SRS has formed a Citizen's Advisory Board to further public involvement.

Currently, SRS is storing PCB-contaminated equipment and cleanup materials for which, due to their radioactive nature, treatment is not currently available. DOE is presently developing this treatment capability and SRS intends to store these PCB-contaminated radioactive equipment and materials onsite until such time as appropriate disposal methods, treatment capacity, and facilities become available. Currently, SRS is storing these PCB-contaminated radioactive materials in an onsite facility that meets storage requirements under 40 CFR 761, but is out of compliance with the provision requiring removal of PCB-contaminated wastes from storage and their disposal within 1 year. As at other DOE sites, DOE is presently working with EPA to approve a treatability study to remove the PCB contamination and the radioactive materials from SRS as LLW.

A.2 PROJECT DESCRIPTIONS

This section contains detailed descriptions of the individual tritium supply and recycling technologies being evaluated in this PEIS. Each supply technology description represents a new facility and the recycling descriptions represent either new or upgraded facilities whose impacts are being considered in evaluating the program alternatives.

Design bases for each of the tritium supply technology options have been previously developed and are as follows:

- **Heavy Water Reactor (HWR)**—All requirement documents developed in the New Production Reactor program for the HWR.
- **Modular High Temperature Gas-Cooled Reactor (MHTGR)**—All requirement documents developed in the New Production Reactor program for the MHTGR.
- **Advanced Light Water Reactor (ALWR)**—All requirements developed for the New Production Reactor program and the data, as gathered, from the Surplus Fissile Materials program.
- **Accelerator Production of Tritium (APT)**—All requirement documents developed in the Tritium Supply and Recycling program for the APT as amended.

Each of the facility designs will, to the extent possible, incorporate the following objectives: maximum operational efficiency, ability to incorporate future technological advances, and ability to meet changing operating requirements. The upgrades/modifications option is designed to renovate existing tritium recycling facilities at SRS to meet mission requirements while complying with all ES&H criteria.

The conceptual designs described in the following sections for the various tritium supply and recycling facilities were based on the following assumptions:

- The design would be based on a normal production rate to meet anticipated baseline tritium requirements (3/8 New Production Reactor goals).
- The enduring stockpile would consist of a mix of systems equivalent to the following existing weapons programs: B61, B83, W76, W78, W80, W87, and W88.
- The facilities would be designed to produce only materials or components required for nuclear weapons programs. The exception is the tritium recycling facility, which would provide tritium for commercial sales.
- The tritium facilities would be capable of producing materials and assembling new building components for two weapon systems in any given year. This capability would be achieved by either simultaneous or sequential campaigns, as long as the sum of the product shipments for the year meets the annual production goals.

A.2.1 Tritium Supply

Tritium, a radioactive form of hydrogen gas, is an essential component of all the warheads in the existing and projected nuclear weapons stockpile. Since it decays at a rate of 5.5 percent per year (12.3-year half-life), the tritium in fielded weapons must be replenished periodically. In addition, because of its decay, the existing national inventory of tritium will become insufficient to meet projected nuclear weapon stockpile requirements around the end of the next decade. This means that a source of new tritium will be needed to prevent degradation of the national nuclear deterrent capability.

The last operating tritium supply reactor, K-Reactor at SRS, has been placed in cold standby with no planned provision for restart. Therefore, DOE is evaluating the construction of a new tritium supply facility. There are a number of candidate tritium production technologies under consideration that could fulfill this mission. Each of these technologies has strengths and weaknesses that are dependent on: selected site, tritium production capacity, and/or supporting infrastructure. The technologies under con-

sideration are listed below and will be discussed in the following sections:

- HWR;
- MHTGR;
- ALWR; and
- Linear Induction Accelerator, herein after referred to as APT.

A.2.1.1 Heavy Water Reactor

Mission. The primary mission of the HWR facility would be to provide the full range of tritium supply functions performed by DOE, as well as waste treatment functions related to HWR operations.

Assumptions. The assumptions used in the design of this facility are listed in section A.2.

General Functions and Layout. The HWR facility would produce tritium by bombarding an isotope of the element lithium with neutrons produced by nuclear fission reactions in uranium. The interaction of neutrons with the lithium creates an unstable lithium isotope that decays almost instantaneously to tritium and an alpha particle. The HWR facility would consist of the following major components: the reactor, target and fuel fabrication, tritium target processing, interim spent nuclear fuel storage, general service, and waste treatment. Figure A.2.1.1-1 depicts the HWR tritium production process and figure A.2.1.1-2 shows the HWR facility site plan. This figure shows a mechanical draft cooling tower system.

Component Facility Functions

Reactor. The reactor would be based on a low-pressure, low-temperature application of nuclear fission technology specifically designed to produce tritium. The reactor vessel and cooling system configuration (with primary and secondary cooling loops) would be similar to that used in commercial light water reactor nuclear power technology. The HWR would use heavy water as the reactor coolant and moderator. Heavy water, circulated through the core for cooling and moderation, also passes through heat exchangers that are external to the reactor tank.

The heat is in turn carried away by the secondary cooling system. The heavy water in the tank surrounding the fuel would represent the bulk moderator. Less than 10 percent of the reactor heat would be generated in the moderator space because of gamma heating; the bulk of the heat would be generated in the core.

The major engineered safety features would include the reactor containment building; the emergency core cooling system to provide makeup coolant flow heat removal for an extended period, following either a loss-of-coolant accident or a loss-of-pumping accident; emergency shutdown safety rods independent of the control rods; neutron poison injection of gadolinium nitrate into the moderator space of the reactor tank; and a backup residual heat removal system capable of removing decay heat from the reactor if the primary coolant fails to circulate.

Engineered safety features of the HWR also include natural circulation cooling by the primary and secondary coolant systems and the boiling pot mode. The boiling pot mode would occur by circulation through the core of the water in which the system is submerged following complete discharge of the Borated Light-Water Reactor Storage Tank; the core will be cooled by a two-phase flow. Steam generated by this process condenses on the containment shell and interior structures. The condensate replenishes the water at the bottom of the containment. The containment shell is cooled by convective flow of outside air which flows between the steel containment and the concrete shield. All the engineered safety features combined would provide a "walk-away" design of the HWR to prevent and/or mitigate a beyond design basis accident event (severe accident).

A circulating ventilation system with atmospheric driers would be used to collect and control tritiated water vapor during normal operation, thus reducing leakage of tritium. The containment system would include such features as heat removal sprays, hydrogen igniters, and long-term residual heat removal systems to mitigate potential radiological releases under severe accident conditions. The initial heavy water inventory for an HWR is available from existing inventories at SRS.

Because of the relatively low exit coolant temperature in the HWR, a power conversion system would not be feasible. The heat dissipation system would ensure that the reactor is cooled by the flow of water circulated through the core in a closed primary loop under pressure through the reactor vessel and through coolant pipes connected in parallel to heat exchangers. The heat dissipation system selected, wet or dry, would be dependent on site characteristics. Both wet and dry cooling systems would use water as the heat exchange medium. Wet systems would use water towers and the evaporation process to carry off heat. Dry systems, designed for cold climates, would use water in closed nonevaporative cooling towers to carry off heat to the atmosphere by conduction through radiator-like vanes. In moderate climates, fans would be added to the dry cooling towers to move air over the vanes. There would be some water loss through evaporation in a dry system, but significantly less than with a wet tower. Dry cooling towers would be used for the reactors at all dry sites.

Target and Fuel Fabrication Facility. The concentric tubes of lithium-aluminum and of uranium-aluminum would be fabricated and assembled into tritium target/fuel assemblies in the target and fuel fabrication facility. The facility would include areas for alloying, casting, machining, extrusion, inspection, and assembly. Auxiliary services would include a maintenance shop, an electronic and instrumentation shop, offices, and a metallurgical and chemical laboratory. There would also be several small storage buildings nearby for lithium and aluminum components. The facility would be designed to control the spread of contamination and prevent the uncontrolled release of radioactive material to the environment.

Tritium Target Processing Facility. After irradiation and cooling in the spent fuel pool, the tritium target tubes would be withdrawn from the assemblies and sent to the tritium target processing facility for tritium extraction. The facility would house the processes, laboratory, and other activities associated with tritium handling. Most of the process operations and hot laboratory analyses would be performed in nitrogen-blanketed gloveboxes to ensure tritium containment. The hot cell would contain two or more vacuum furnaces for extracting tritium from the irradiated targets. Airlocks would separate the furnaces from the rest of the hot cell.

Interim Spent Nuclear Fuel Storage Facility. Spent nuclear fuel would be sent to, and stored underwater at, the interim spent fuel storage facility.

General Service Facility. The general service facility would contain the control equipment and various plant support equipment.

Waste Treatment Facility. The waste treatment facility would receive all solid, liquid, and gaseous radioactive waste for storage, treatment, and packaging for either release or disposal at an appropriate permanent waste disposal facility.

Description of Processes

Tritium Target and Fuel Production. Lithium-aluminum tritium target alloy would be formed into billets and preextruded into logs which would then be machined and nested into coextrusion billets. These billets would then be coextruded to produce the target tubes. The uranium-aluminum fuel alloy would be similarly formed into fuel tubes and then nested with the target tubes into the tritium target/fuel assemblies described earlier.

Tritium Production. The tritium target/fuel assemblies would be loaded into the reactor and irradiated. When the irradiation is complete, the assemblies would be removed and shipped to the disassembly basin.

Tritium Extraction. At the disassembly basin, the target tubes would be separated from the fuel tubes and allowed to cool so that short-lived isotopes could decay. A 1-month cooling period for tritium targets is assumed. After cooling, the target tubes would be washed within the shielded transport cask, then placed in a crucible, inserted into a furnace, and heated to drive off the gases, including the tritium product. The gas stream from the furnace, mainly helium and hydrogen isotopes, including tritium, would pass through a diffusing process to separate the hydrogen isotopes from helium and other impurities. This process would cycle the gas between two beds of treated diatomaceous earth used as a filter aid. One bed would be heated to drive off the gases; the other bed would be cooled to promote gas absorption. The purified tritium would be sent to the tritium recycling facility, where tritium reservoirs are filled.

Facility Utilities. Facility construction and operation utility requirements are shown in tables A.2.1.1-1 and A.2.1.1-2, respectively.

Chemicals Required. Table A.2.1.1-3 depicts chemical resources required during operation.

Personnel Requirements. Construction of the HWR would have a peak employment of 2,320 construction workers. Approximately 9,760 worker years would be needed during the 8-year construction period. Operation of the HWR would require 930 workers with 230 of these badged for radiation detection.

Transportation. Interfacility transfers would be made by rail, truck transport, or pipeline, as appropriate. Truck service would be needed for intrafacility transport.

Waste Management. The solid and liquid nonhazardous wastes generated during construction would include concrete and steel construction waste materials and sanitary wastewater. The steel construction waste would be recycled as scrap material before completing construction. The remaining nonhazardous wastes generated during construction would be disposed of as part of the construction project by the contractor. Uncontaminated wastewater would be used for soil compaction and dust control, and excavated soil would be used for grading and site preparation. Wood, paper, and metal wastes would be shipped offsite to a commercial contractor for recycling. Hazardous wastes generated during construction would consist of such materials as waste adhesives, oils, cleaning fluids, solvents, and coatings. Hazardous waste would be packaged in Department of Transportation (DOT) approved containers and shipped offsite to commercial RCRA-permitted treatment, storage, and disposal facilities. No radioactive waste would be generated during construction.

The facility design considers and incorporates waste minimization and pollution prevention. Activities that generate radioactive and hazardous wastes would be segregated, where possible, to avoid the generation of mixed wastes. Where applicable, treatment to separate radioactive and nonradioactive components would be performed to reduce the volume of mixed wastes and provide for cost-

effective disposal or recycling. To facilitate waste minimization, where possible, nonhazardous materials would be substituted for those materials that generate hazardous or mixed waste. Production processes would be configured with minimization of waste production given high priority. Material from the waste streams would be treated to facilitate disposal as nonhazardous wastes, where possible. Future D&D considerations would also be incorporated into the design.

Table A.2.1.1-4 presents the estimated annual spent nuclear fuel and waste volumes from the HWR facility during construction and operation. Solid and liquid waste streams would be routed to the waste management system. Figure A.2.1.1-3 depicts the waste management system at a dry site while figure A.2.1.1-4 illustrates the waste management system for a wet site. Solid wastes would be characterized and segregated into LLW, hazardous, and mixed wastes, then treated to forms suitable for disposal or storage within the facility. Liquid wastes would be treated onsite to reduce hazardous/toxic and radioactive elements before discharge or transport. All fire sprinkler water discharged in process areas would be contained and treated as process wastewater, when required.

Spent Nuclear Fuel. Spent nuclear fuel would not be reprocessed. Spent nuclear fuel would be initially stored at the spent nuclear fuel storage facility in pools onsite. After the spent nuclear fuel decay heat has decreased sufficiently (approximately 230 days), the nested fuel tubes from four spent nuclear fuel assemblies would be loaded into stainless steel containers in the disassembly area. The loaded containers would be dewatered by displacement with air or an inert gas such as helium or argon and then sealed. The sealed containers would then be transferred to an interim onsite dry storage basin for horizontal emplacement on racks with poison plate separators. The facility design would have sufficient capacity to store the spent nuclear fuel for the life of the facility. The ROD (60 FR 28680) from the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement* has the type of spent nuclear fuel generated by the HWR destined for consolidation at SRS to await availability of a geologic repository.

Transuranic Waste. The HWR would not generate any TRU waste.

Low-Level Waste. LLW would be generated by the operation of the reactor and support facilities. The aqueous releases from fuel and tritium-target fabrication would be liquid LLW from tube-cleaning operations. Process effluents would be temporarily held in storage tanks before treatment into solid LLW that is suitable for LLW disposal. The nonhazardous liquid effluent would then be discharged through a permitted NPDES outfall. The bulk of the solid LLW would be generated in the reactor, fuel fabrication, and tritium target processing facilities. Solid LLW would consist of contaminated equipment pieces, plastic sheeting, protective clothing, solidified slurry from the wastewater treatment facility, spent high efficiency particulate air (HEPA) filters, spent targets, spent catalysts and resins, and spent uranium beds. Solid LLW would be compacted as appropriate and then disposed of in a suitable disposal facility.

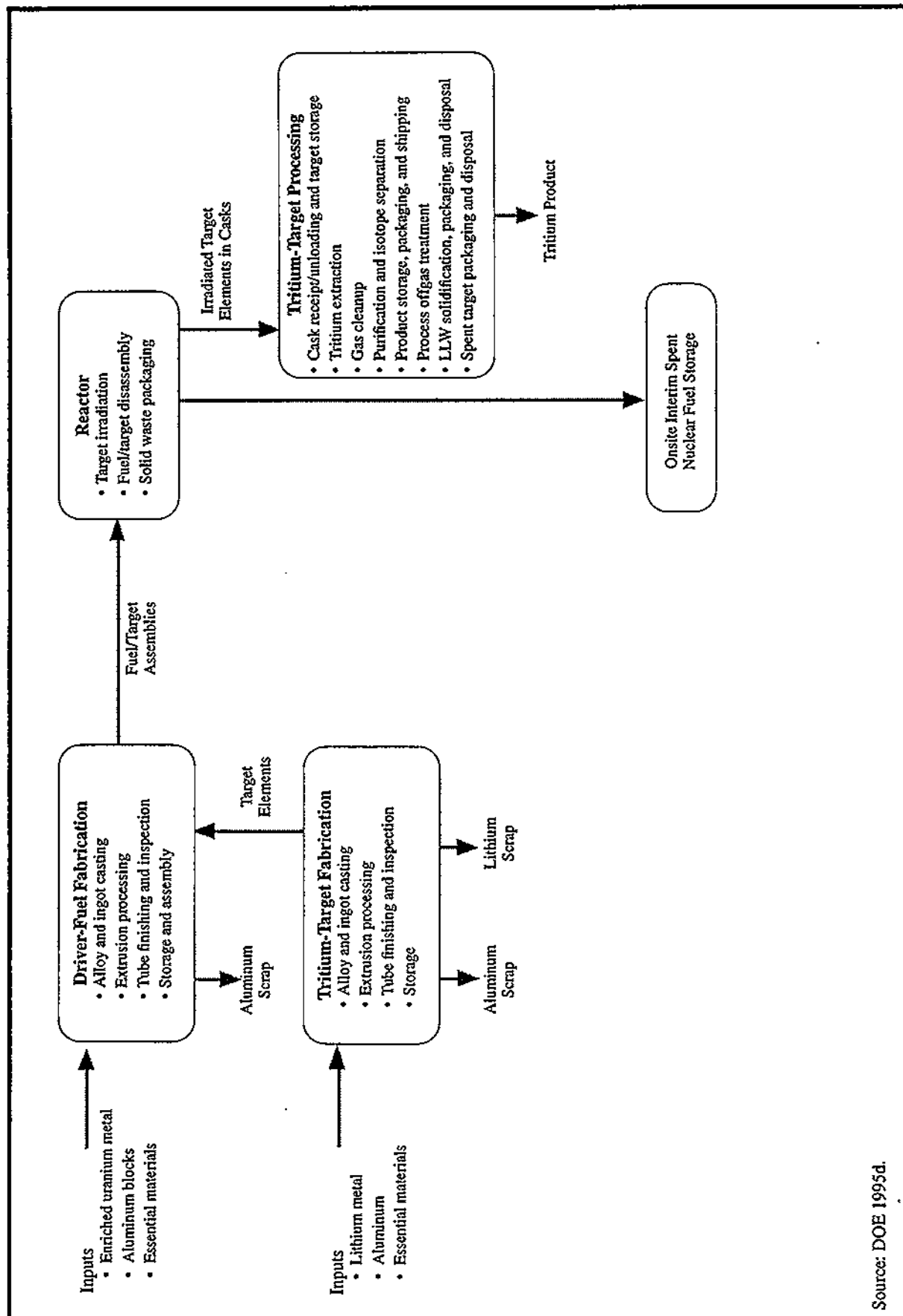
Mixed Low-Level Waste. No liquid mixed LLW would be generated from the HWR facility. Solid mixed LLW may originate from wipes laden with contaminated oils and hydraulic fluids from the tritium extraction facility. Mixed LLW would be stored in an onsite RCRA-permitted storage facility until treatment in accordance with the site-specific treatment plan that was developed to comply with the *Federal Facility Compliance Act* of 1992.

Hazardous Waste. Liquid hazardous wastes would be generated from degreasing agents, cleaning solvents, cutting oils, vacuum pump oils, film processing fluids, hydraulic fluids from mechanical equipment, antifreeze solutions, and paint. The cleaning solvent selected would be from a list of non-halogenated solvents. Liquid hazardous wastes would be collected in DOT-approved containers and sent to an onsite hazardous waste accumulation area. The hazardous waste accumulation area would provide a 90-day staging capacity prior to shipment to an offsite commercial RCRA-permitted treatment, storage, and disposal facility using DOT-certified transporters. Solid hazardous wastes would be

generated from nonradioactive materials such as wipes contaminated with oils, lubricants, and cleaning solvents that are used for equipment outside the main processing units. After compaction, if appropriate, the solid hazardous wastes would be packaged in DOT-approved containers and sent to a hazardous waste accumulation area for staging prior to shipment to an offsite commercial RCRA-permitted treatment, storage, and disposal facility using DOT-certified transporters.

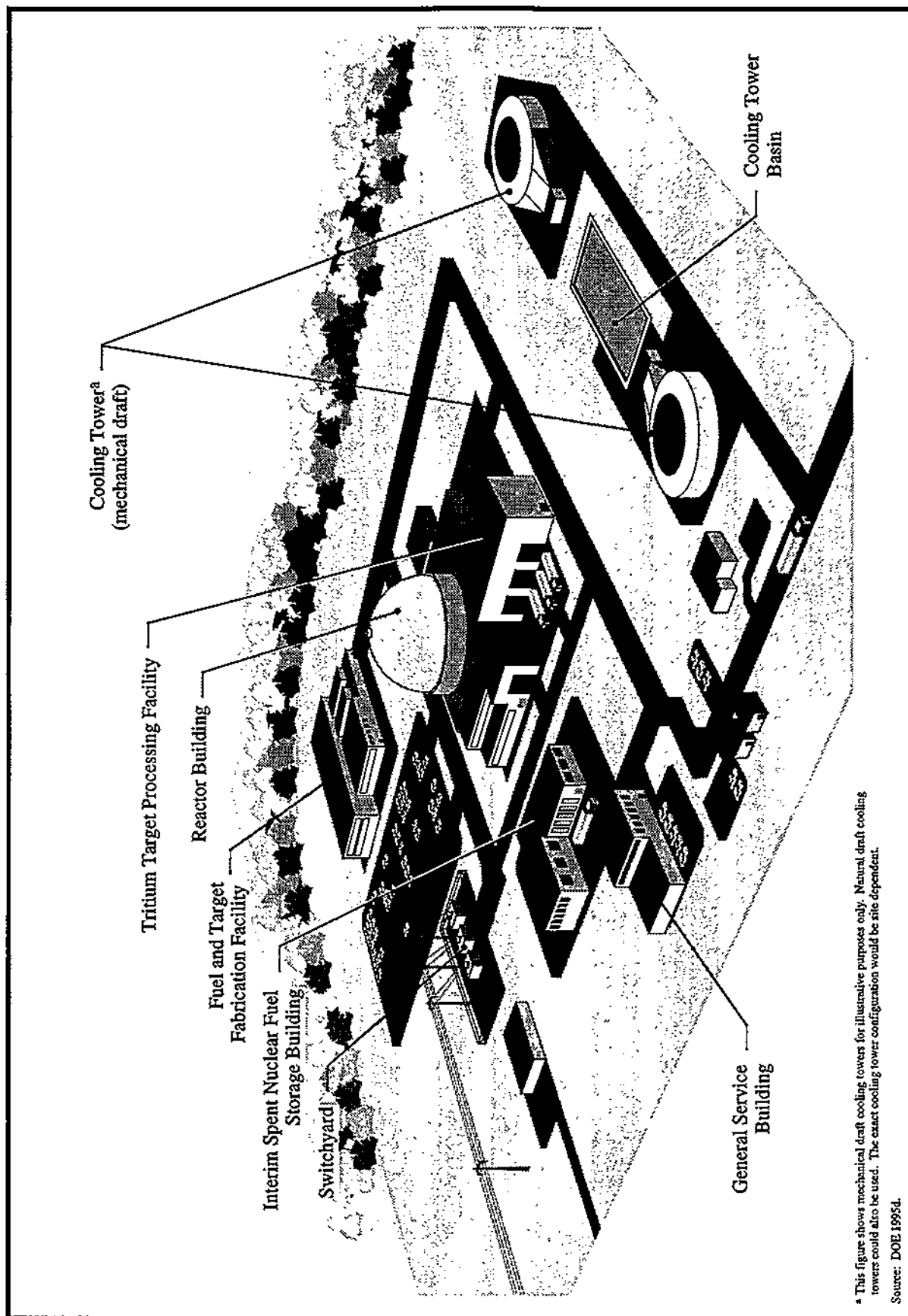
Nonhazardous Waste. Sewage wastewater would be treated in the sanitary wastewater treatment plant. Sewage wastewater is kept separate from all industrial and process wastewaters and normally contains no radioactive wastes from the facility. The sewage wastewater would be routinely monitored for radioactive contaminants. The sewage process sludge would be disposed of in a permitted landfill. All treated effluent would be discharged to a stream or river through an NPDES outfall (wet site) or a natural drainage channel (dry site). Cooling system blowdown would be treated and discharged to the river (wet site). Because the dry site design uses non-evaporative-type cooling towers, there would be no liquid discharges resulting from blowdown. The treated effluent from the utility wastewater treatment would be discharged to the river through an NPDES outfall (wet site) or a natural drainage channel. All sludges would be disposed of in a permitted landfill. Other nonrecyclable, solid, nonhazardous sanitary and industrial wastes would be compacted and disposed of in a permitted landfill.

The facility design includes stormwater retention facilities with the necessary NPDES monitoring equipment. Rainfall within the Limited Area and Protected Area would be collected separately and routed to the stormwater collection ponds and then sampled and analyzed before discharge to the natural drainage channels (dry site) or river (wet site). If the runoff is contaminated, it would be treated in the radioactive waste treatment system. Runoff from the Property Protection Area would be discharged directly into the natural drainage channels or river.



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FIGURE A.2.1.1-1.—Heavy Water Reactor Tritium Production Process.



* This figure shows mechanical draft cooling towers for illustrative purposes only. Natural draft cooling towers could also be used. The exact cooling tower configuration would be site dependent.
Source: DOE 1995d.

22978 App

FIGURE A.2.1.1-2.—Heavy Water Reactor Facility (Typical).

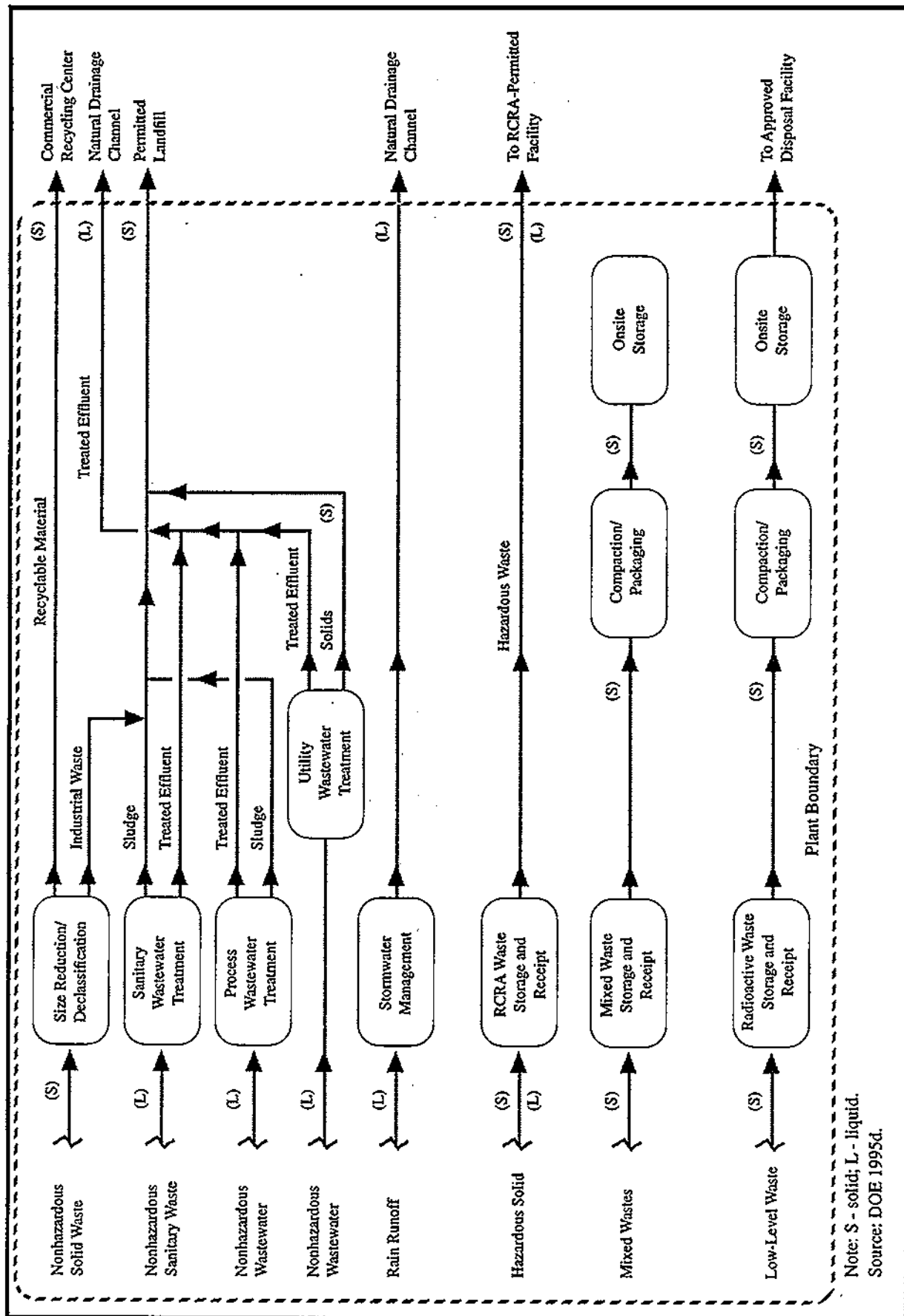


FIGURE A.2.1.1-3.—Heavy Water Reactor Waste Management System (Dry Site).

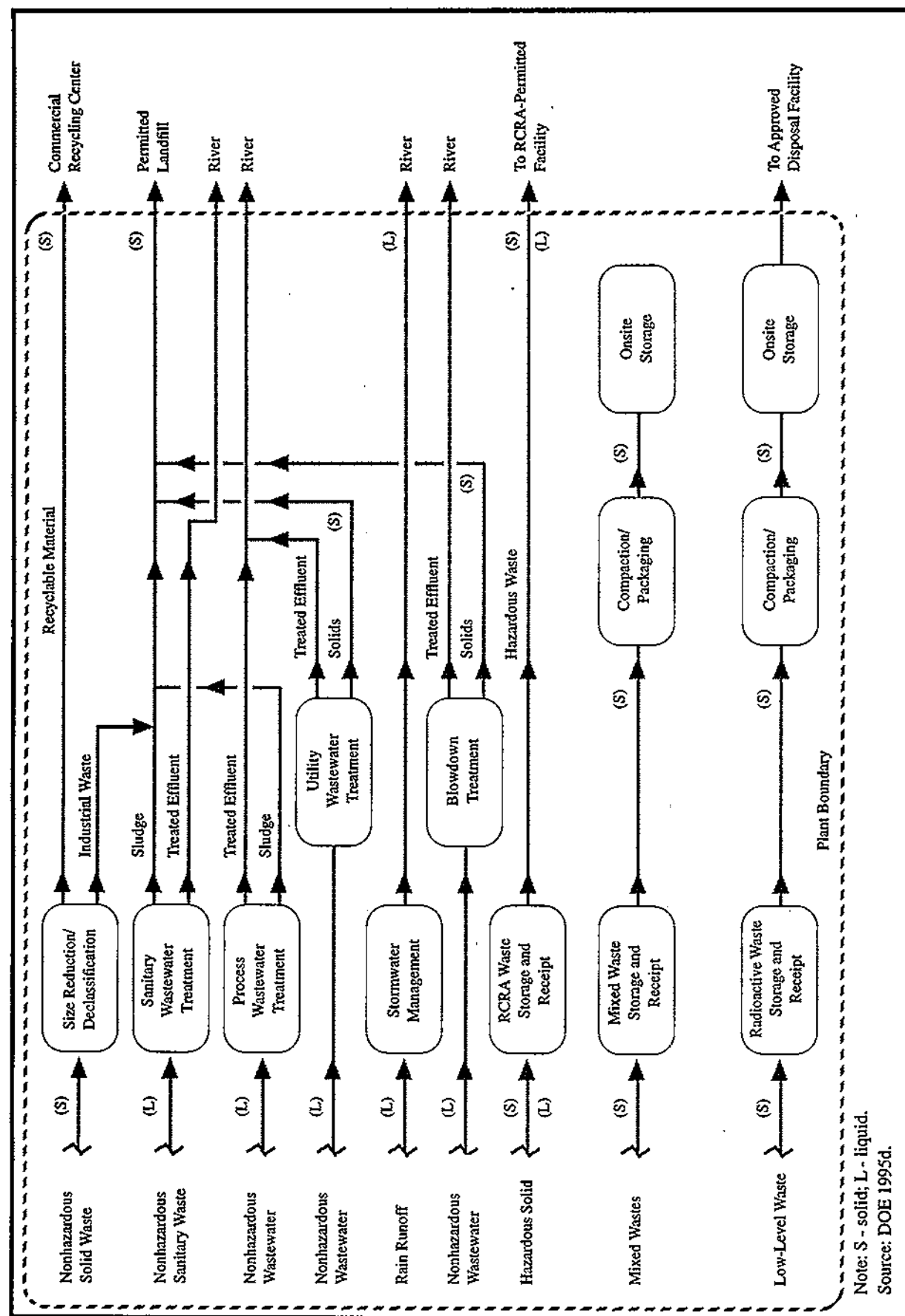


FIGURE A.2.1.1-4.—Heavy Water Reactor Waste Management System (Wet Site).

2303

**TABLE A.2.1.1-1.—Heavy Water Reactor
Construction Material/Resource Requirements**

Material/Resource	Consumption
Electrical Energy (MWh)	87,000
Concrete (yd ³)	220,000
Steel (tons)	45,000
Fuel (gal)	2,400,000
Water (gal)	170,000,000

Source: DOE 1995d.

**TABLE A.2.1.1-2.—Heavy Water Reactor
Operation Utility Requirements**

Utility	Consumption
Electrical Energy (MWh per year)	
Wet site	370,000
Dry site	540,000
Electrical Load (MWe)	
Wet site	51
Dry site	69
Fuel	
Gas (ft ³ per year)	240,000,000
Liquid (GPY)	82,000
Water (MGY)	
Wet site	5,900
Dry site	48

Source: DOE 1995d.

**TABLE A.2.1.1-3.—Heavy Water Reactor
Annual Chemical Requirements**

Chemicals	Quantity (tons)
Aluminum	12
Uranium metal	0.75
Lithium metal	0.08
Stainless steel	0.125
Nitric acid	1.2
Sodium hydroxide	0
Sulfuric acid	0

Source: DOE 1995d.

TABLE A.2.1.1-4.—Heavy Water Reactor Estimated Spent Nuclear Fuel and Waste Volumes

Category	Dry Site			Wet Site		
	Annual Average Volume Generated From Construction (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)	
Spent Nuclear Fuel						
Low-Level						
Liquid	None	7 ^a	7 ^a	7 ^a	7 ^a	
Solid	None	10,400 ^b (2,100,000 gal)	None	10,400 ^b (2,100,000 gal)	None	
Mixed Low-Level						
Liquid	None	5,200	1,870 ^c	5,200	1,870 ^c	
Solid	None	None	None	None	None	
Hazardous						
Liquid	Included in solid	Included in solid	Included in solid	Included in solid	Included in solid	
Solid	20	40	40	40	40	
Nonhazardous (Sanitary)						
Liquid	79,220 (16,000,000 gal)	238,000 (48,000,000 gal)	238,000 (48,000,000 gal)	11,600,000 (2,350,000,000 gal)	11,600,000 (2,350,000,000 gal)	
Solid	7,800	7,600	2,530 ^d	7,600	2,530 ^d	
Nonhazardous (Other)						
Liquid	2,570 ^e (520,000 gal)	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary	
Solid	Included in sanitary	6,500 ^f	None	6,500 ^f	None	

^a Residual heavy metal content in spent nuclear fuel is 660 lb (0.3 metric tons).

^b Liquid LLW is treated with the remaining LLW sludge being solidified.

^c Assumes a 100:1 wastewater/sludge ratio in the treatment of liquid LLW, followed by 2:1 increase in volume from solidification of sludge. Assumes compaction factor of 3:1 for compactible solids.

^d Assumes overall compaction factor of 3:1.

^e Does not include groundwater dewatering, if required.

^f Recyclable wastes.

Source: DOE 1995d.

A.2.1.2 *Modular High Temperature Gas-Cooled Reactor*

Mission. The primary mission of the MHTGR facility would be to provide the full range of tritium supply functions performed by DOE, as well as waste treatment functions related to MHTGR operations.

Assumptions. The assumptions used in the design of this facility are listed in section A.2.

General Functions and Layout. The MHTGR would produce tritium by bombarding an isotope of the element lithium with neutrons produced by nuclear fission reactions in uranium. The interaction of neutrons with the lithium creates an unstable lithium isotope that decays almost instantaneously to tritium and an alpha particle. The MHTGR facility would consist of the following components: the specified number of reactors (three reactors are analyzed in this PEIS), target and fuel fabrication, tritium target processing, interim spent fuel storage, general service, waste treatment, and power conversion. Figure A.2.1.2-1 depicts the MHTGR tritium production process while figure A.2.1.2-2 shows the MHTGR facility site plan.

Component Facility Functions. The MHTGR would be sized (i.e., the number of reactors) and designed for a specific tritium supply capability based on reasonably foreseeable long-term requirements.

Reactor. Each individual reactor would be a moderate pressure, high temperature device designed to produce tritium. A reactor includes its vessel, a steam generator, a helium circulator, and interconnecting cross ducts housed in the reinforced concrete containment structure. The reactor vessel would contain the core, control rods and drives, the reflector, and the core supports. Top-mounted standpipes would house the control rod drives and the reserve shutdown system. A shutdown circulator mounted at the bottom of the core would provide cooling when the main circulator is out of service for maintenance. The core size and shape provide for natural convection heat transfer through to the pressure vessel walls in the event of the loss of circulation or if the pressure boundary is breached for any reason. Core power would be controlled by moveable control rods containing boron carbide as a nuclear poison. Reserve shutdown would consist of boronated graphite pellets normally contained in hoppers above the core. When

needed, they would be dropped into holes in the fuel blocks, shutting down the nuclear reaction.

Helium would be used as the coolant and graphite would provide the core structure and act as moderator. The coolant would be pumped by an electrically driven circulator located above the steam generator. The reactor core would be housed in a steel pressure vessel. A cross vessel would direct the helium to the steam generator. The helium heated by the core would flow over the steam generator tube bundle, giving up its heat to the feedwater, and producing superheated steam. This steam would be of sufficient quality that it could be used for the production of electricity. When shut down for maintenance or refueling, the decay heat of the core would be removed either by the normal cooling system, or by the shutdown cooling system, with its own circulator and independent heat exchanger.

In the event of transients that would increase reactor fuel temperature, the increased temperature would decrease the power level. This would work two ways in that the mass of the core would absorb the additional heat generated, and as the temperature gradually rises, power would decrease. Even in the event of the loss of coolant at full power, the reactor would return to a lower temperature, core geometry would be maintained, and control rod insertion would not be hampered. Predictable reactor response and long time constants are a product of the high heat capacity of the core and the lack of phase changes in the primary coolant. All this would occur without the need for operator intervention.

The heat dissipation system selected, wet or dry, would depend on site characteristics. Both wet and dry cooling systems would use water as the heat exchange medium. Wet systems would use water towers and the evaporation process to carry off heat. Dry systems, designed for cold climates, would use water in closed nonevaporative cooling towers to carry off heat by conduction to the atmosphere through radiator-like vanes. In moderate climates, fans would be added to the dry cooling towers to move air over these vanes. There would be some water loss through evaporation in a dry system, but significantly less than with a wet tower. Dry cooling towers would be used for the reactors at all dry sites. The use of wet cooling towers would be an option only for the power conversion facility and only when the facility would be located at a wet site.

Target and Fuel Fabrication Facility. The target and fuel rods would be assembled for irradiation in the reactor. After irradiation, the assemblies would be returned for separation of the target and fuel rods.

Tritium Target Processing Facility. Spent nuclear fuel rods would be sent to interim storage and the target rods would be sent to the tritium processing facility, which houses the processes, laboratory, and other activities associated with the production of tritium gas including a hot cell for receiving, storing, and processing irradiated target rods.

Interim Spent Nuclear Fuel Storage Facility. This facility consists of three water-cooled fuel storage basins paired with individual reactors. Fuel elements containing spent fuel would be stored in dry canisters for up to 3 years in the storage basins. After the cooling period, the spent fuel elements would be encapsulated and then transferred to dry storage vaults for the life of the plant.

Power Conversion Facility. This facility would consist of a fully independent turbine generator for each reactor. It would also include a maintenance building, makeup water treatment and auxiliary boiler building, station cooling towers, station transformers, circulating water pump house, and electric switchyard.

General Service Facility. This facility would contain the control equipment and various plant support equipment.

Waste Treatment Facility. This facility would receive all solid, liquid, and gaseous radioactive waste for storage, treatment, and packaging for either release or disposal at an appropriate permanent waste disposal facility.

Descriptions of Processes

Tritium Target Fabrication. Targets would be fabricated from pyrocarbon-coated lithium aluminate microspheres. The compacts would be loaded into graphite sleeves that are subsequently loaded into graphite blocks similar to those used to hold the fuel rods.

Tritium Production. The fuel and target blocks would be loaded into the reactor and irradiated.

When the irradiation is complete, the blocks would be removed and the target compacts would be separated from the fuel and sent to the tritium extraction facility for further processing.

Tritium Extraction. The tritium in the irradiated target compacts would be extracted by heating and captured by chemical absorption. The spent targets would be disposed of as waste. The tritium would be transferred to the tritium recycling facility.

Facility Utilities. Facility construction and operation utility requirements are shown in tables A.2.1.2-1 and A.2.1.2-2 respectively.

Chemicals Required. Table A.2.1.2-3 lists chemical resources required during operation.

Personnel Requirements. Construction of the MHTGR would have a peak employment of 2,210 construction workers. Approximately 8,810 worker-years would be needed during the 9-year construction period. Operation of the MHTGR would require 910 workers with 180 of these badged for radiation detection.

Transportation. Interfacility transfers would be made by rail, truck transport, or pipeline as appropriate. Truck service would be needed for intrafacility transport.

Waste Management. The solid and liquid nonhazardous wastes generated during construction would include concrete and steel construction waste materials and sanitary wastewater. The steel construction waste would be recycled as scrap material before completing construction. The remaining nonhazardous wastes generated during construction would be disposed of as part of the construction project by the contractor. Uncontaminated wastewater would be used for soil compaction and dust control, and excavated soil would be used for grading and site preparation. Wood, paper, and metal wastes would be shipped offsite to a commercial contractor for recycling. Hazardous wastes generated during construction would consist of such materials as waste adhesives, oils, cleaning fluids, solvents, and coatings. Hazardous waste would be packaged in DOT-approved containers and shipped offsite to commercial RCRA-permitted treatment, storage, and

disposal facilities. No radioactive waste would be generated during construction.

The facility design considers and incorporates waste minimization and pollution prevention. Activities that generate radioactive and hazardous wastes would be segregated, where possible, to avoid the generation of mixed wastes. Where applicable, treatment to separate radioactive and nonradioactive components would be performed to reduce the volume of mixed wastes and provide for cost-effective disposal or recycling. To facilitate waste minimization, where possible, nonhazardous materials would be substituted for those materials that contribute to the generation of hazardous or mixed waste. Production processes would be configured with minimization of waste production given high priority. Material from the waste streams would be treated to facilitate disposal as nonhazardous wastes, where possible. Future D&D considerations would also be incorporated into the design.

Table A.2.1.2-4 presents the estimated annual spent nuclear fuel and waste volumes from the MHTGR during construction and operation. Solid and liquid waste streams would be routed to the waste management system. Figure A.2.1.2-3 depicts the waste management system at a dry site while figure A.2.1.1-4 illustrates the waste management system for a wet site. Solid wastes would be characterized and segregated into low-level, hazardous, and mixed wastes, then treated to a form suitable for disposal or storage within the facility. Liquid wastes would be treated onsite to reduce hazardous/toxic and radioactive elements before discharge or transport. All fire sprinkler water discharged in process areas would be contained and treated as process wastewater, when required.

Spent Nuclear Fuel. Spent nuclear fuel would not be reprocessed. Following removal from the reactor, spent nuclear fuel would be stored in the spent fuel storage wells in the reactor service building. After a 3-year cooling period, a fuel-handling machine would load spent nuclear fuel elements, one at a time, into a fuel cylinder. The cylinder would be plugged at each end with suitable shielding and filled with helium. After the end plates were welded on, the cylinder would then be leak-tested. The cylinder would be inserted into a dry storage canister. After the canister is filled with seven fuel cylinders, it

would be filled with helium, welded shut, and leak-tested. To remove the dry storage canister from the reactor service building, specially designed equipment would be used to grapple the canister and insert it into a truck-mounted transfer cask. At the storage facility, the canister would be placed into a horizontal concrete storage module. The module would include a passive ventilation system for decay heat removal, metal heat shields to protect the strength of the concrete, and temperature monitors and alarms. These modules would be arrayed on slab-on-grade basemats in a rectangular configuration near the reactor service building. The facility design would have sufficient capacity to store the spent nuclear fuel for the life of the facility. The ROD (60 FR 28680) from the *DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement* has the type of spent nuclear fuel generated by the MHTGR destined for consolidation at INEL to await availability of a geologic repository.

Transuranic Waste. The MHTGR would not generate any TRU waste.

Low-Level Waste. LLW would be generated by the operation of the reactor and support facilities. Process effluents would be temporarily stored in storage tanks before treatment into solid LLW that is suitable for LLW disposal. The nonhazardous liquid effluent would then be discharged through a permitted NPDES outfall. The bulk of the solid LLW would be generated in the tritium target processing facility. Solid LLW would consist of contaminated equipment pieces, spent targets, spent uranium beds, plastic sheeting, spent resins, spent HEPA filters, and protective clothing. Solid LLW would be compacted as appropriate and then disposed of in a suitable disposal facility.

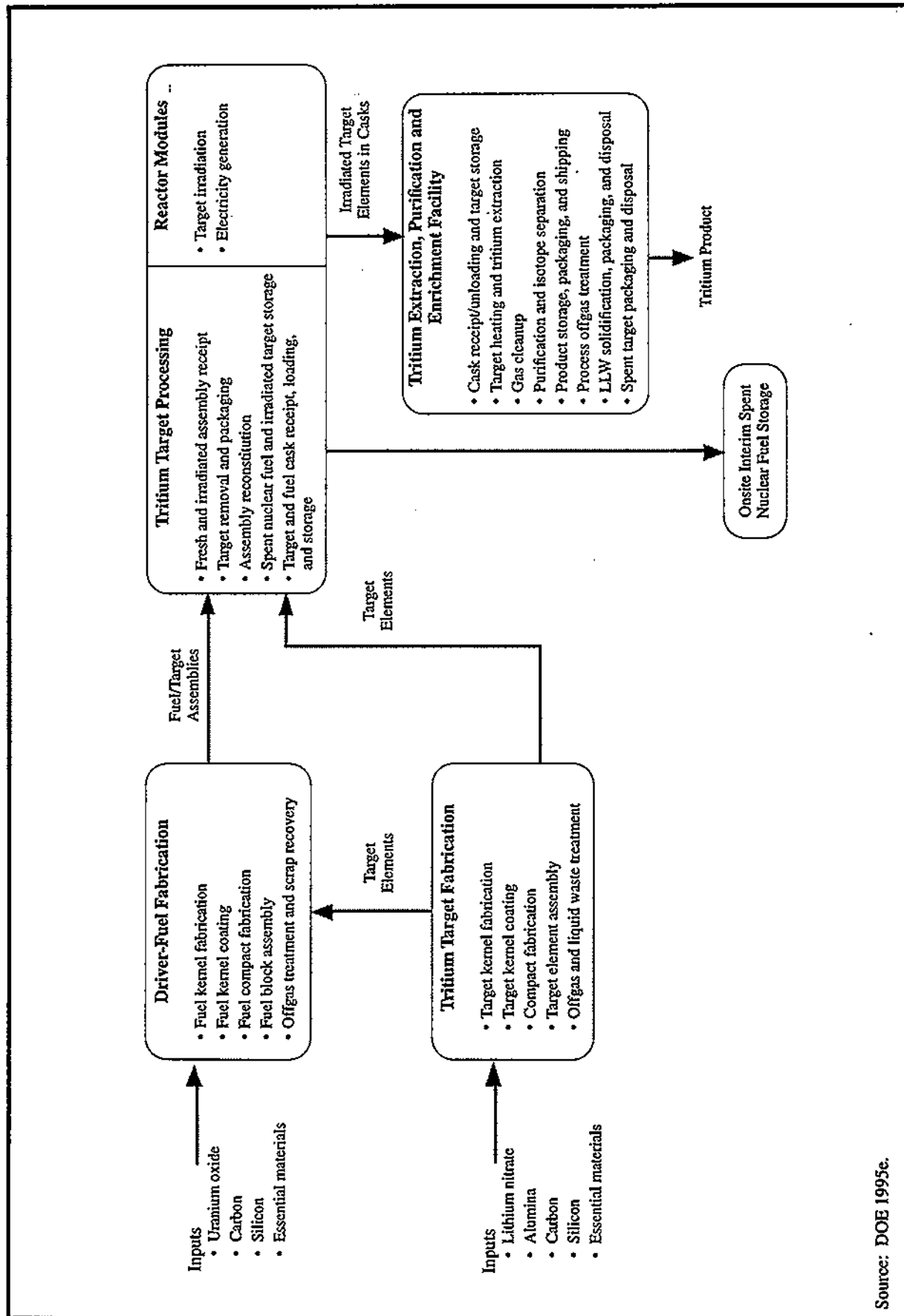
Mixed Low-Level Waste. No liquid mixed LLW would be generated from the MHTGR. Solid mixed LLW may originate from wipes laden with contaminated oils and hydraulic fluids from the tritium extraction facility. Mixed LLW would be stored in an onsite RCRA-permitted facility until treatment in accordance with the site-specific treatment plan that was developed to comply with the *Federal Facility Compliance Act* of 1992.

Hazardous Waste. Liquid hazardous wastes would be generated from cleaning solvents, cutting oils, vacuum pump oils, film processing fluids, hydraulic fluids from mechanical equipment, antifreeze solutions, acids, and paint. The cleaning solvent selected for use would be from a list of nonhalogenated solvents. Liquid hazardous wastes would be collected in DOT-approved containers and sent to a hazardous waste accumulation area. The hazardous waste accumulation area would provide a 90-day staging capacity prior to shipment to an offsite commercial RCRA-permitted treatment, storage, and disposal facility using DOT-certified transporters. Solid hazardous wastes would be generated from nonradioactive materials such as wipes contaminated with oils, lubricants, and cleaning solvents that are used for equipment outside the main processing units. After compaction, if appropriate, the solid hazardous wastes would be packaged in DOT-approved containers and sent to a hazardous waste accumulation area for staging prior to shipment to an offsite commercial RCRA-permitted treatment, storage, and disposal facility using DOT-certified transporters.

Nonhazardous Waste. Sewage wastewater would be treated in the sanitary wastewater treatment plant. Sewage wastewater would be kept separate from all industrial and process wastewaters and normally contains no radioactive wastes from the facility. The

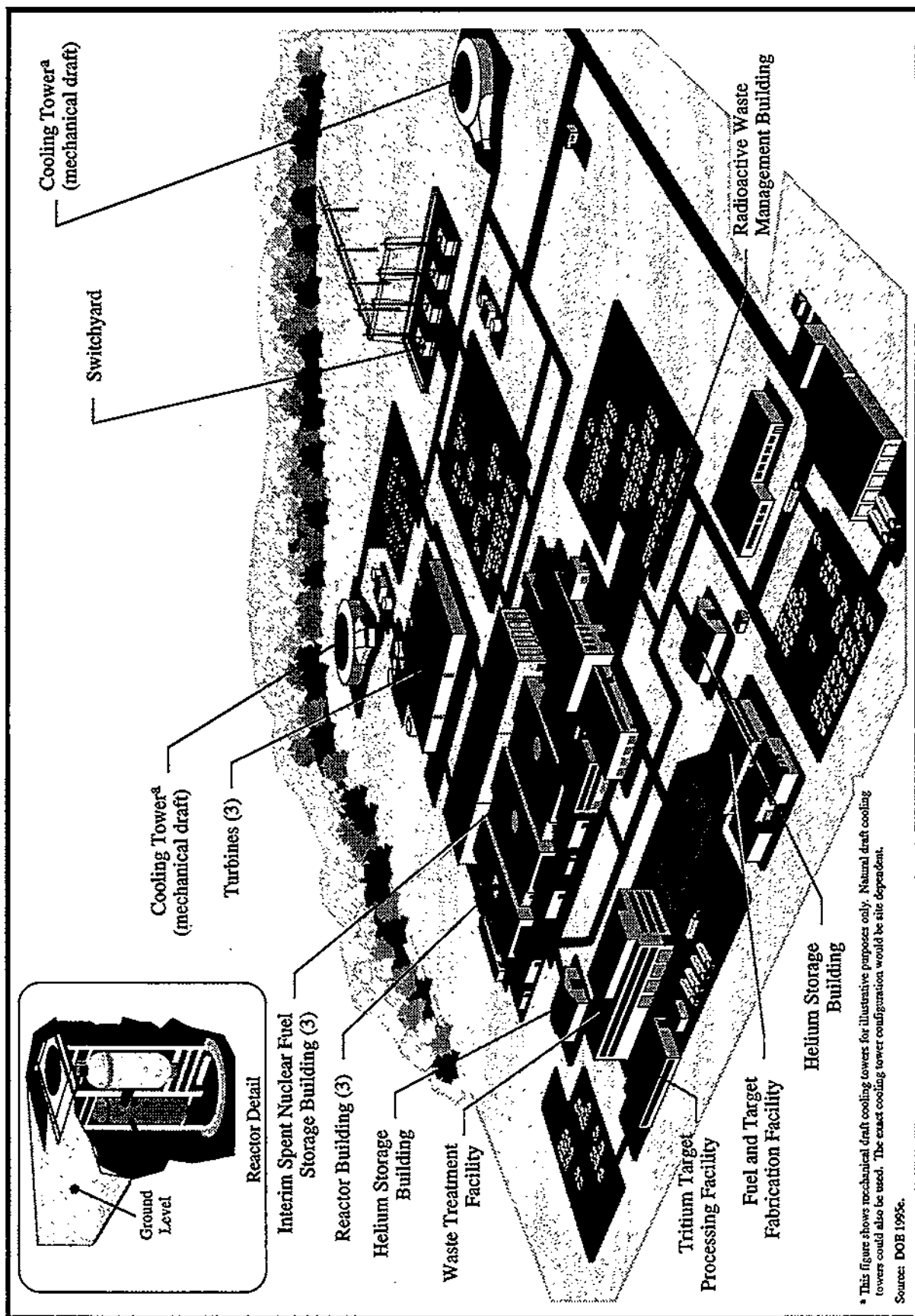
sewage wastewater would be routinely monitored for radioactive contaminants. The sludge would be disposed of in a permitted sanitary landfill. All treated effluent would be discharged to a stream or river through an NPDES outfall (wet site) or a natural drainage channel (dry site). Cooling tower blowdown would be treated and discharged to the river (wet site). Because the dry site design uses non-evaporative type cooling towers, there would be no liquid discharges resulting from blowdown. The treated effluent from the utility wastewater treatment would be discharged to the river through an NPDES outfall (wet site) or a natural drainage channel. All sludges would be disposed of in a permitted landfill. Other nonrecyclable, solid nonhazardous sanitary and industrial wastes would be compacted and disposed of in a permitted landfill.

The facility design includes stormwater retention facilities with the necessary NPDES monitoring equipment. Rainfall within the Limited Area and Protected Area would be collected separately and routed to the stormwater collection ponds and then sampled and analyzed before discharge to the natural drainage channels (dry site) or river (wet site). If contaminated, the runoff would be treated in the radioactive waste treatment system. Runoff from the Property Protection Area would be discharged directly into the natural drainage channel or river.



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FIGURE A.2.1.2-1.—Modular High Temperature Gas-Cooled Reactor Tritium Production Process.



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FIGURE A.2.1.2-2.—Modular High Temperature Gas-Cooled Reactor Facility (Typical).

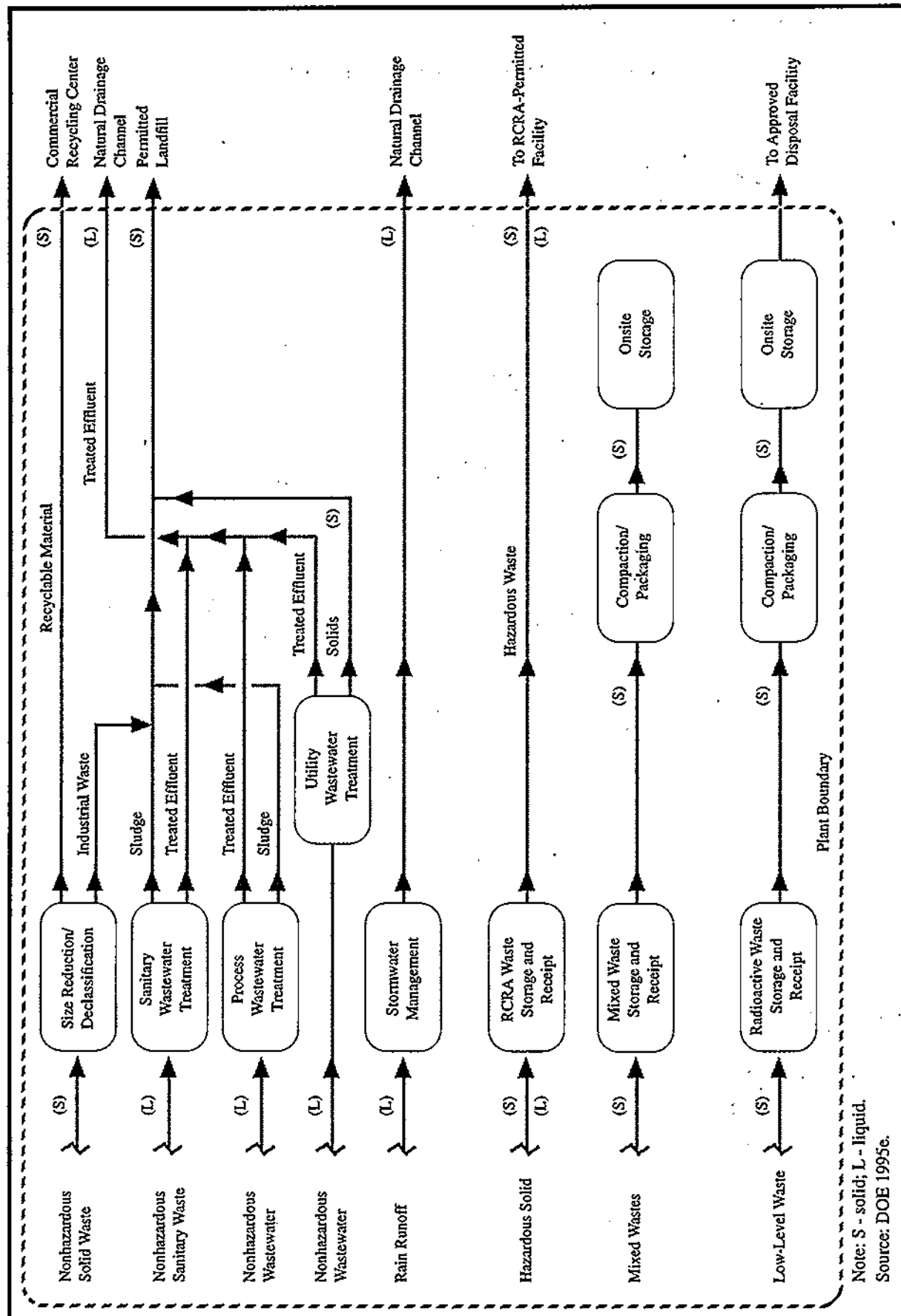


FIGURE A.2.1.2-3.—Modular High Temperature Gas-Cooled Reactor Waste Management System (Dry Site).

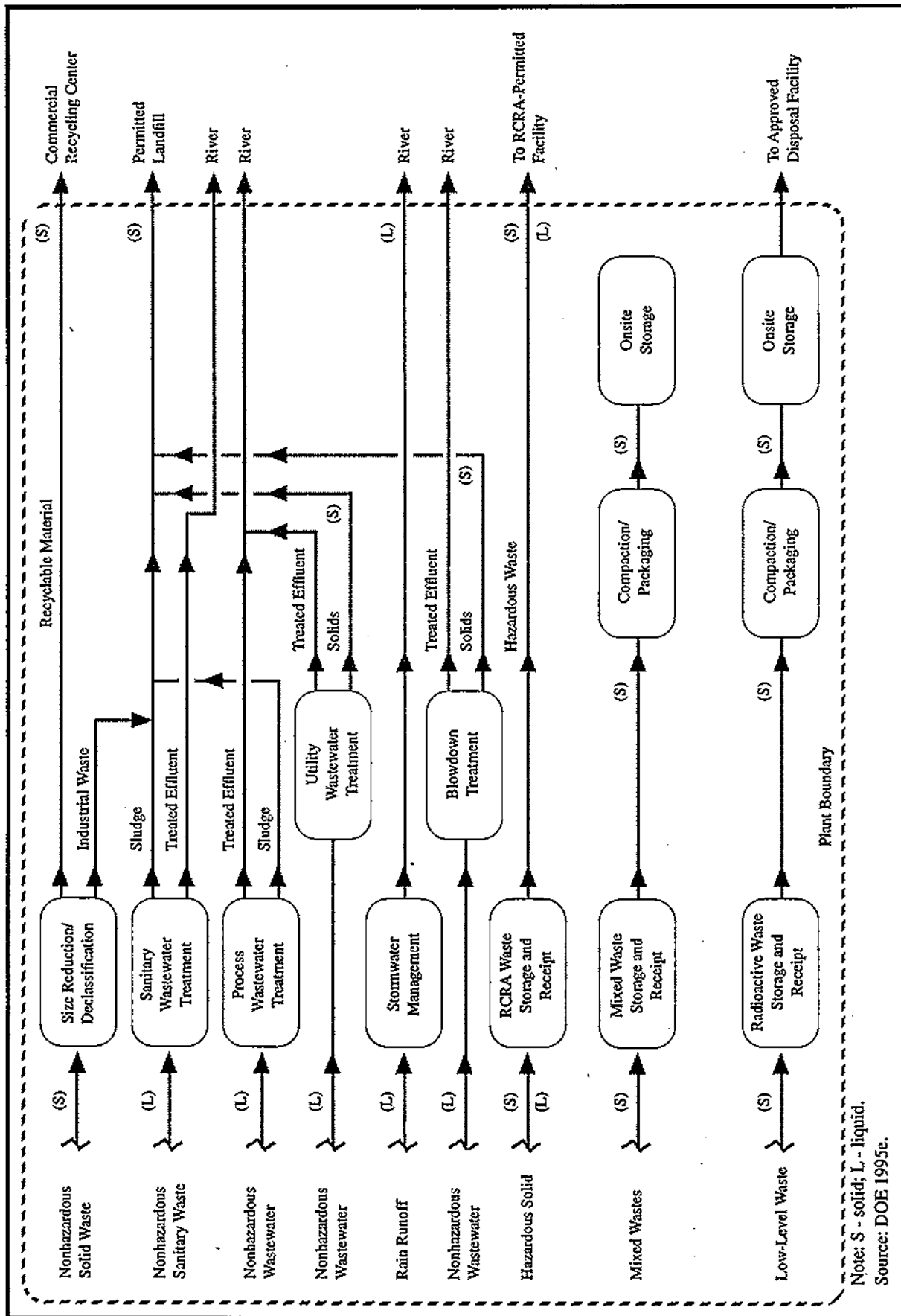


FIGURE A.2.1.2-4.—Modular High Temperature Gas-Cooled Reactor Waste Management System (Wet Site).

TABLE A.2.1.2-1.—Modular High Temperature Gas-Cooled Reactor Construction Material/Resource Requirements

Material/Resource	Consumption
Electrical energy (MWh)	73,000
Concrete (yd ³)	220,000
Steel (tons)	60,000
Fuel (gal)	3,200,000
Water (gal)	160,000,000

Source: DOE 1995e.

TABLE A.2.1.2-2.—Modular High Temperature Gas-Cooled Reactor Operation Utility Requirements

Utility	Consumption
Electrical Energy (MWh per year)	260,000
Wet site	360,000
Dry site	
Electrical Load (MWe)	
Wet site	36
Dry site	46
Fuel	
Gas (ft ³ per year)	6,000,000
Liquid (GPY)	81,000
Water (MGY)	
Wet site	4,000
Dry site	30

Source: DOE 1995e.

TABLE A.2.1.2-3.—Modular High Temperature Gas-Cooled Reactor Annual Chemical Requirements

Chemical	Quantity (tons)
Aluminum oxide	2
Uranium oxide	1.1
Lithium nitrate	1.4
Stainless steel	0.08
Nitric acid	49
Sodium hydroxide	1.1
Sulfuric acid	0
Graphite	122

Source: DOE 1995e.

TABLE A.2.1.2-4.—Modular High Temperature Gas-Cooled Reactor Estimated Spent Nuclear Fuel and Waste Volumes

Category	Dry Site			Wet Site		
	Annual Average Volume Generated From Construction (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)	Annual Volume From Operations (yd ³)
Spent Nuclear Fuel						
Low-Level						
Liquid	None	80 ^a	80 ^a	80 ^a	80 ^a	80 ^a
Solid	None	2,600 ^b (525,000 gal)	None	2,600 ^b (525,000)	None	None
Mixed Low-Level						
Liquid	None	1,300	468 ^c	1,300	468 ^c	468 ^c
Solid	None	None	None	None	None	None
Hazardous						
Liquid	None	<1	<1	<1	<1	<1
Solid	Included in solid	Included in solid	Included in solid	Included in solid	Included in solid	Included in solid
Nonhazardous (Sanitary)						
Liquid	20	100	100	100	100	100
Solid	64,400 (13,000,000 gal)	149,000 (30,000,000 gal)	149,000 (30,000,000 gal)	8,070,000 (1,630,000,000 gal)	8,070,000 (1,630,000,000 gal)	8,070,000 (1,630,000,000 gal)
Nonhazardous (Other)						
Liquid	7,100	7,400	2,470 ^d	7,400	2,470 ^d	2,470 ^d
Solid	3,020 ^e (610,000 gal)	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary
	Included in sanitary	6,400 ^f	None	6,400 ^f	None	None

^a Residual heavy metal content in spent nuclear fuel is 530 lb (0.24 metric tons).

^b Liquid LLW is treated with the remaining LLW sludge being solidified.

^c Assumes a 100:1 wastewater/sludge ratio in the treatment of liquid LLW, followed by 2:1 increase in volume from solidification of sludge. Assumes compaction factor of 3:1 for compactible solids.

^d Assumes overall compaction factor of 3:1.

^e Does not include groundwater dewatering, if required.

^f Recyclable wastes.

Source: DOE 1995e.

A.2.1.3 Advanced Light Water Reactor

Mission. The primary mission of the ALWR facility would be to provide the full range of tritium supply functions performed by DOE, as well as waste treatment functions related to ALWR operations.

Assumptions. The assumptions used in the design of this facility are listed in section A.2.

General Functions and Layout. The ALWR would produce tritium by bombarding an isotope of the element lithium with neutrons produced by nuclear fission reactions in uranium. The interaction of neutrons with lithium creates an unstable lithium isotope that decays almost instantaneously to tritium and an alpha particle. Two ALWR design approaches, based on rated power (large and small reactor, designated Large ALWR and Small ALWR in the following discussion), are under consideration. For either design, the ALWR facility would consist of the following major components: the reactor, tritium target processing, interim spent fuel storage, power conversion, and waste treatment. Figure A.2.1.1-1 depicts the ALWR tritium production process, while figure A.2.1.3-2 shows a typical ALWR facility site plan.

There are two 1,300 MWe Large ALWR designs under consideration: the large pressurized water reactor and the large boiling water reactor. Two 600-MWe Small ALWR design concepts are also under consideration: a small pressurized water reactor and a small boiling water reactor.

Component Facility Functions.

Reactor. The reactor would be an improved version of existing commercial electric power generating reactors and would operate at or near rated power. An ALWR would use ordinary (light) water as both the moderator and coolant. Modifications to the design for tritium production would be minimal, with the principal modification being the replacement of a fraction of the fuel rods by target rods. The enrichment of the remaining fuel rods would be increased to compensate for the missing fuel rods, but derating of core power might be necessary. The core, contained within a steel pressure vessel, would be composed of bundles of fuel and target rods. The fuel rods would consist of tubes of zircaloy cladding filled

with uranium dioxide fuel pellets, while the target rods would consist of steel clad lithium aluminate. Target rods would be removed from the core and replaced with new target rods once a year. Fuel rods would be obtained from offsite sources, while target rods would be fabricated onsite.

The heat dissipation system selected, wet or dry, would depend on site characteristics. Both wet and dry cooling systems would use water as the heat exchange medium. Wet systems would use water towers and the evaporation process to carry off heat. Dry systems, designed for cold climates, would use water in closed nonevaporative cooling towers, to carry off heat by conduction to the atmosphere through heat exchangers. In moderate climates, fans would be added to the dry cooling towers to move air over the vanes of the heat exchangers. There would be some water loss through evaporation in a dry system, but significantly less than with a wet tower. Dry cooling towers would be used for the reactors at all dry sites. The use of wet cooling towers would be an option only for the power conversion facility and only when the facility would be located at a wet site.

Tritium Target Fabrication Facility. This building would house the facilities and equipment needed to produce lithium-aluminate target rods.

Tritium Target Processing Facility. After irradiation and a cooling period, the target rods are processed to remove the tritium. The facility houses the processes, laboratory, and other activities associated with handling irradiated elements and is also designed to control the spread of contamination within the facilities and prevent the uncontrolled release of radioactive material to the environment.

Interim Spent Nuclear Fuel Storage Facility. Spent nuclear fuel would be sent to, and stored underwater at the interim spent fuel storage facility.

Power Conversion Facility. This facility would contain a turbine generator, electrical equipment, control equipment, auxiliary systems, plant support systems, and other equipment.

Waste Treatment Facility. This facility would receive all solid, liquid, and gaseous radioactive waste for storage, treatment, and packaging for either release

or disposal at an appropriate permanent waste disposal facility.

Description of Processes

Tritium Target and Fuel Production. Fuel rod fabrication would be done offsite by commercial sources. Tritium-target rod fabrication begins with lithium carbonate and aluminum-oxide, which are blended, calcined, pressed into thin, annular, ceramic pellets, and sintered. The pellets are then ground to size, inspected, preassembled with the getter, and loaded into target rods clad in reactor grade stainless steel having an inner coat of aluminide. The rods are dried, backfilled with helium, and welded shut. The target rods are placed in containers and transported to the off-site fuel and target assembly facility where the target rods, fuel rods, and associated hardware are assembled into a fuel and target assembly. The fuel and target assemblies are shipped to the ALWR tritium supply plant.

Tritium Production. Tritium would be produced within the steel clad lithium aluminate target rods, contained in fuel bundles in the reactor core. After about one year, when sufficient tritium would have collected within the target rods, the target rods would be removed from the reactor and placed in the interim fuel storage pool for approximately 1 month to allow for the decay of short-lived radioactive nuclides to acceptable levels. Target rods would then be sent to the onsite tritium extraction facility.

Tritium Extraction. The tritium target rods would be removed from the storage pool and sent to the main hot cell. In the hot cell, the target tubes would be heated in a furnace to drive off the tritium, helium, and hydrogen gases. This gas stream would pass through a diffuser to separate the hydrogen isotopes from the other gases.

Facility Utilities. Bounding values for the Large ALWR and the Small ALWR facility construction and operation utility requirements are shown in tables A.2.1.3-1 and A.2.1.3-2, respectively.

Chemicals Required. Table A.2.1.3-1 depicts chemical resources required during operation.

Personnel Requirements. Construction of the ALWR would have a peak employment of

3,500 construction workers for a Large ALWR and 2,200 workers for a Small ALWR. Approximately 12,600 worker-years would be needed for a Large ALWR and 7,100 worker years for a Small ALWR during the 6-year construction period. Operation of the Large ALWR would require 830 workers of which 210 would be badged. The Small ALWR would require 500 workers of which 125 would be badged.

Transportation. Interfacility transfers would be made by rail, truck transport, or pipeline, as appropriate. Truck service would be needed for intrafacility transport.

Waste Management. The solid and liquid nonhazardous wastes generated during construction would include concrete and steel construction waste materials and sanitary wastewater. The steel construction waste would be recycled as scrap material before completing construction. The remaining nonhazardous wastes generated during construction would be disposed of as part of the construction project by the contractor. Uncontaminated wastewater would be used for soil compaction and dust control, and excavated soil would be used for grading and site preparation. Wood, paper, and metal wastes would be shipped offsite to a commercial contractor for recycling. Hazardous wastes generated during construction would consist of such materials as waste adhesives, oils, cleaning fluids, solvents, and coatings. Hazardous wastes would be packaged in DOT-approved containers and shipped offsite to commercial RCRA-permitted treatment, storage, and disposal facilities. No radioactive waste would be generated during construction.

The facility design considers and incorporates waste minimization and pollution prevention. Activities that generate radioactive and hazardous wastes would be segregated, where possible, to avoid the generation of mixed wastes. Where applicable, treatment to separate radioactive and nonradioactive components would be performed to reduce the volume of mixed wastes and provide for cost-effective disposal or recycle. To facilitate waste minimization, where possible, nonhazardous materials would be substituted for those materials that contribute to the generation of hazardous or mixed waste. Production processes would be configured with minimization of waste production given high priority.

Material from the waste streams would be treated to facilitate disposal as nonhazardous wastes, where possible. Future D&D considerations would also be incorporated into the design.

Tables A.2.1.3-4 and A.2.1.3-5 present the estimated annual spent nuclear fuel and waste volumes from the ALWR, Large and Small, respectively, during construction and operation. Solid and liquid waste streams would be routed to the waste management system. Figure A.2.1.3-3 depicts the waste management system at a dry site while figure A.2.1.3-4 illustrates the waste management system for a wet site. Solid wastes would be characterized and segregated into LLW, hazardous, and mixed wastes, then treated into a form suitable for disposal or storage within the facility. Liquid wastes would be treated onsite to reduce hazardous/toxic and radioactive elements before discharge or transport. All fire sprinkler water discharged in process areas would be contained and treated as process wastewater, when required.

Spent Nuclear Fuel. Spent nuclear fuel would not be reprocessed. Fuel elements containing spent nuclear fuel would be stored for up to three years in water-cooled storage basins. The spent nuclear fuel pool would be equipped with an underwater canister loading system. Twelve spent nuclear fuel assemblies would be placed in fixed positions in a borated aluminum or stainless-steel basket for criticality safety. The basket would be contained in a canister whose lids would be seal-welded in place. After the 3-year cooling period, the canisters would be drained, vacuum dried, and backfilled with helium through lid penetrations in preparation for dry storage. The canisters would be transferred in a cask to the interim spent nuclear fuel storage facility. At the storage facility the canisters would be transferred into the final storage cask which would be made of precast concrete and would hold one canister each. Casks would be placed on a concrete basemat. Periodic visual inspections of the canisters and the cask vents would be required. Periodic testing for helium leaks might also be required. The facility design would have sufficient capacity to store the spent nuclear fuel for the life of the facility. The ROD (60 FR 28680) from the *DOE Programmatic Spent Nuclear Fuel Management and the Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Envi-*

ronmental Impact Statement has the type of spent nuclear fuel generated by the ALWR destined for consolidation at SRS to await availability of a geologic repository.

Transuranic Waste. The ALWR would not generate any TRU waste.

Low-Level Waste. LLW would be generated by the operation of the reactor and support facilities. Process effluents would be temporarily stored in storage tanks before treatment into solid LLW that is suitable for disposal. The nonhazardous liquid effluent would then be discharged through a permitted NPDES outfall. The bulk of the solid LLW would then be generated in the reactor and tritium target processing facilities. Solid LLW would consist of contaminated equipment pieces, plastic sheeting, spent targets, spent uranium beds, and protective clothing. It would be compacted as appropriate and then disposed of in a suitable disposal facility.

Mixed Low-Level Waste. No liquid mixed LLW would be generated from operating the ALWR. Solid mixed LLW may originate from wipes laden with contaminated oils and hydraulic fluids from the tritium extraction facility. Mixed LLW would be stored in an onsite RCRA-permitted storage facility until treatment in accordance with the site-specific treatment plan that was developed to comply with the *Federal Facility Compliance Act* of 1992.

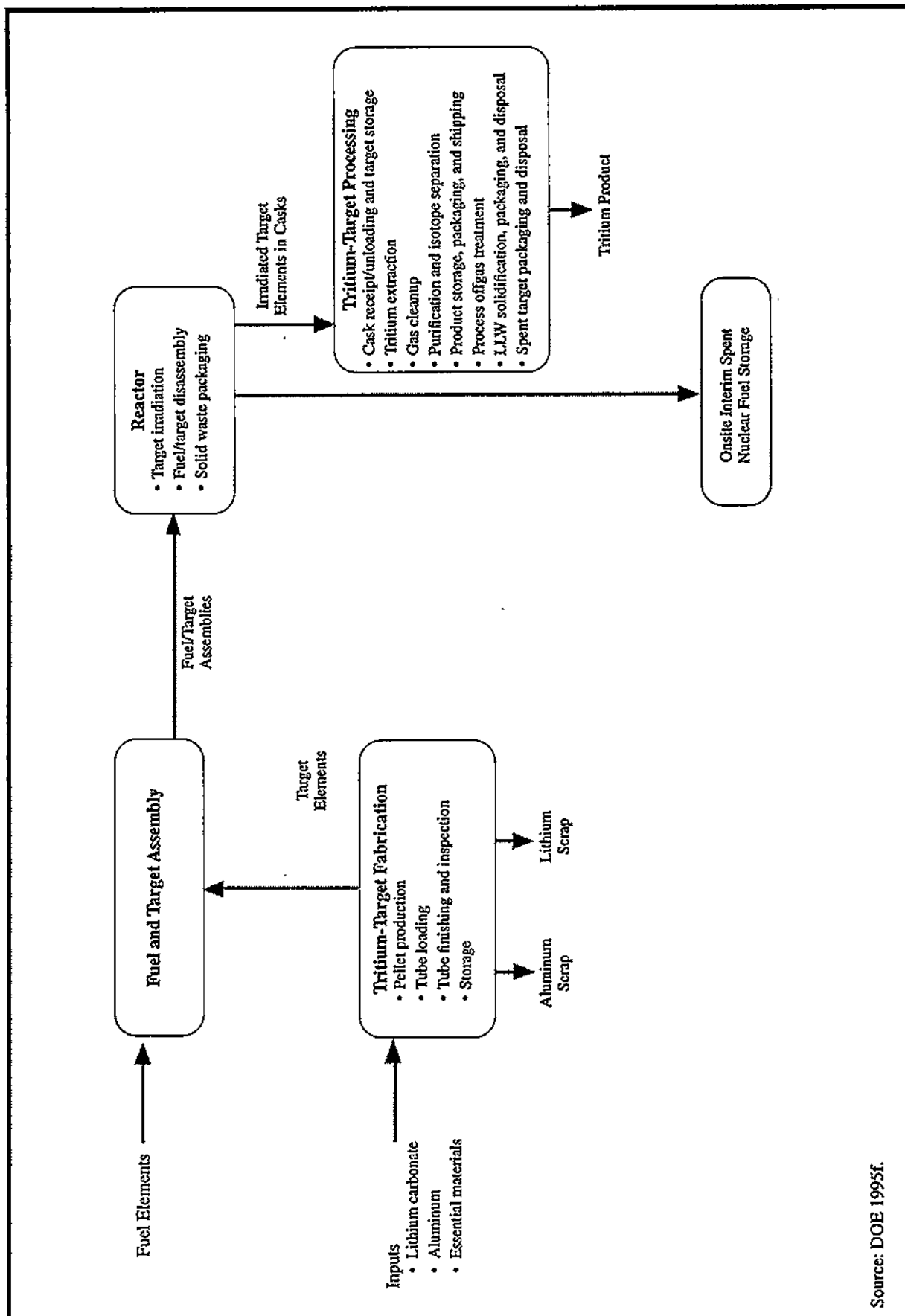
Hazardous Waste. Liquid hazardous wastes would be generated from cleaning solvents, cutting oils, vacuum pump oils, film processing fluids, hydraulic fluids from mechanical equipment, antifreeze solutions, acids, and paint. The cleaning solvent selected for use would be from a list of nonhalogenated solvents. Liquid hazardous wastes would be collected in DOT-approved containers and sent to an onsite hazardous waste accumulation area. The hazardous waste accumulation area would provide a 90-day staging capacity prior to shipment to an offsite commercial RCRA-permitted treatment, storage, and disposal facility using DOT-certified transporters. Solid hazardous wastes would be generated from nonradioactive materials such as wipes contaminated with oils, lubricants, and cleaning solvents that are used for equipment outside the main processing units. After compaction, if appropriate, the solid hazardous wastes would be

packaged in DOT-approved containers and sent to a hazardous waste accumulation area for staging prior to shipment to an offsite commercial RCRA-permitted treatment, storage, and disposal facility using DOT-certified transporters.

Nonhazardous Waste. Sewage wastewater would be treated in the sanitary wastewater treatment plant. Sewage wastewater would be kept separate from all industrial and process wastewaters and normally contains no radioactive wastes from the facility. The sewage wastewater would be routinely monitored for radioactive contaminants. The sewage process sludge would be disposed of in a permitted landfill. All treated effluent would be discharged to a stream or river through an NPDES outfall (wet site) or a natural drainage channel (dry site). Cooling tower blowdown would be treated and discharged to the river (wet site). Because the dry site design uses non-evaporative-type cooling towers, there are no liquid discharges resulting from blowdown. The treated

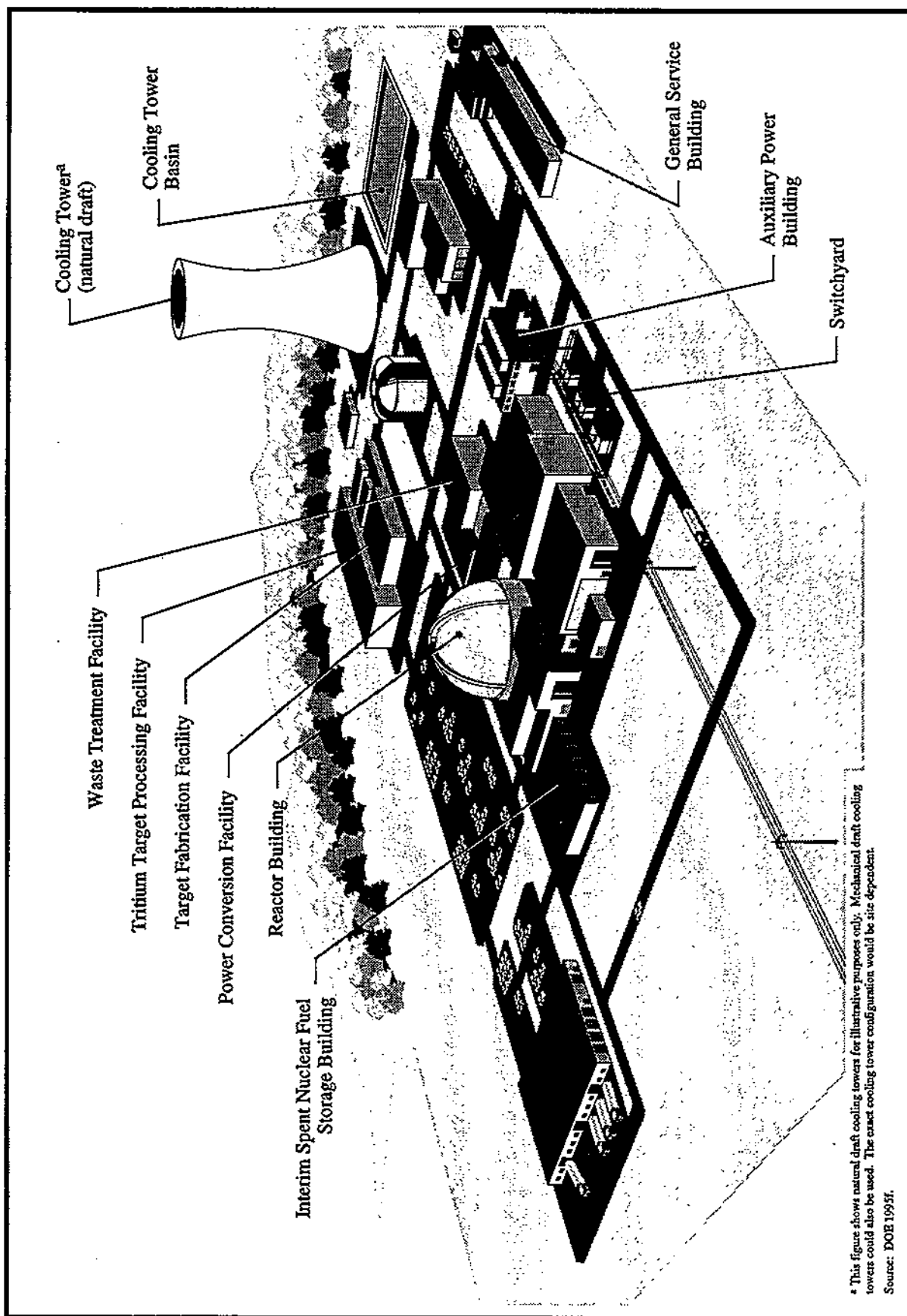
effluent from the utility wastewater treatment would be discharged to the river through an NPDES outfall (wet site) or a natural drainage channel (dry site). All sludges would be disposed of in a permitted landfill. Other nonrecyclable, solid nonhazardous sanitary and industrial waste would be compacted and disposed of in a permitted landfill.

The facility design includes stormwater retention ponds with the necessary NPDES monitoring equipment. Rainfall within the Limited Area and Protected Area would be collected separately and routed to the stormwater collection ponds and then sampled and analyzed before discharge to the natural drainage channels (dry site) or river (wet site). If the runoff is contaminated, it would be treated in the radioactive waste treatment system. Runoff from the Property Protection Area would be discharged directly into the natural drainage channels or river.



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FIGURE A.2.1.3-1.—Advanced Light Water Reactor Tritium Production Process.



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FIGURE A.2.1.3-2.—Advanced Light Water Reactor Facility (Typical).

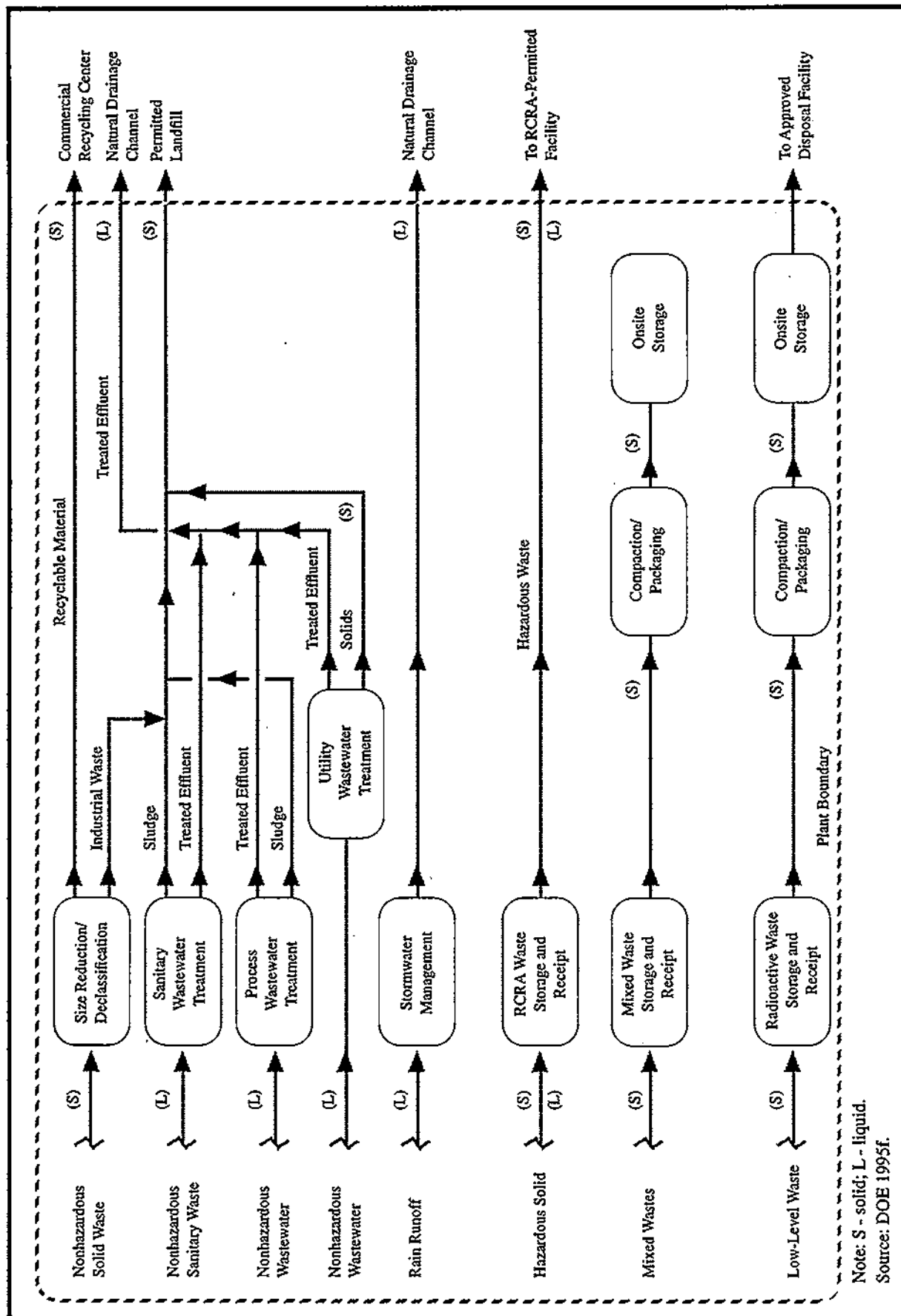


FIGURE A.2.1.3-3—Advanced Light Water Reactor Waste Management System (Dry Site).

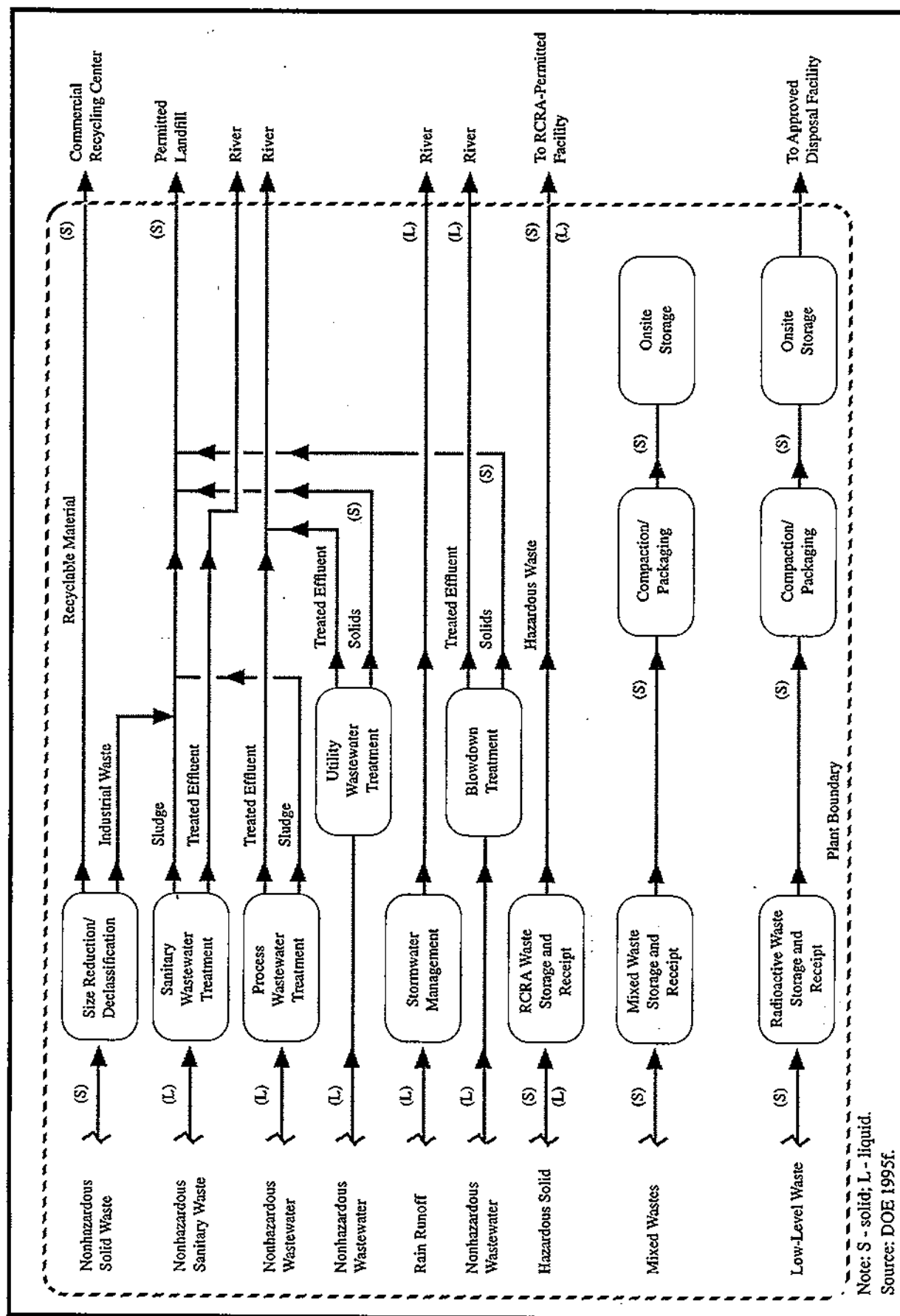


FIGURE A.2.1.3.4.—Advanced Light Water Reactor Waste Management System (Wet Site).

TABLE A.2.1.3-1.—Advanced Light Water Reactor Construction Material/Resource Requirements

Material/ Resource	Consumption	
	Large	Small
Electrical energy (MWh)	120,000	120,000
Concrete (yd ³)	380,000	200,000
Steel (tons)	68,000	50,000
Fuel (gal)	1,500,000	1,500,000
Water (gal)	200,000,000	120,000,000

Source: DOE 1995f.

TABLE A.2.1.3-2.—Advanced Light Water Reactor Operation Utility Requirements

Utility	Consumption	
	Large	Small
Electrical Energy (MWh/yr)		
Wet site	700,000	380,000
Dry site	1,100,000	580,000
Electrical Load (MWe)		
Wet site	96	52
Dry site	140	75
Fuel		
Gas (ft ³ /yr)	0	0
Liquid (GPY)	200,000	110,000
Water (MGY)		
Wet site	16,000	7,200
Dry site	90	50

Source: DOE 1995f.

TABLE A.2.1.3-3.—Advanced Light Water Reactor Annual Chemical Requirements

Chemical	Quantity (tons)	
	Large	Small
Aluminum oxide	0.9	0.9
Uranium oxide	0	0
Lithium carbonate	0.65	0.65
Stainless steel	8.5	4.65
Nitric acid	0.13	0.13
Sodium hydroxide	0	0
Sulfuric acid	0	0

Source: DOE 1995f.

TABLE A.2.1.3-4.—Advanced Light Water Reactor (Large) Estimated Spent Nuclear Fuel and Waste Volumes

Category	Dry Site			Wet Site		
	Annual Average Volume Generated From Construction (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)	
Spent Nuclear Fuel	None	55 ^a	55 ^a	55 ^a	55 ^a	
Low-Level						
Liquid	None	24,800 ^b (5,000,000 gal)	None	24,800 ^b (5,000,000 gal)	None	
Solid	None	710	567 ^c	710	567 ^c	
Mixed Low-Level						
Liquid	None	None	None	None	None	
Solid	None	6	6	6	6	
Hazardous						
Liquid	Included in solid	Included in solid	Included in solid	Included in solid	Included in solid	
Solid	930	35	35	35	35	
Nonhazardous (Sanitary)						
Liquid	134,000 (27,000,000 gal)	446,000 (90,000,000 gal)	446,000 (90,000,000 gal)	31,100,000 (6,290,000,000 gal)	31,100,000 (6,290,000,000 gal)	
Solid	15,000	6,900	2,300 ^d	6,900	2,300 ^d	
Nonhazardous (Other)						
Liquid	2,480 ^e (500,000 gal)	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary	
Solid	Included in sanitary	5,800 ^f	None	5,800 ^f	None	

^a Residual heavy metal content in spent nuclear fuel is 230,000 lb (105 metric tons).^b Liquid LLW is treated with the remaining LLW sludge being solidified.^c Assumes a 100:1 wastewater/sludge ratio in the treatment of liquid LLW, followed by 2:1 increase in volume from solidification of sludge. Assumes compaction factor of 3:1 for compactible solids.^d Assumes overall compaction factor of 3:1.^e Does not include groundwater dewatering, if required.^f Recyclable wastes.

Source: DOE 1995f.

TABLE A.2.1.3-5.—Advanced Light Water Reactor (Small) Estimated Spent Nuclear Fuel and Waste Volumes

Category	Dry Site			Wet Site		
	Annual Average Volume Generated From Construction (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)
Spent Nuclear Fuel	None	36 ^a	36 ^a	36 ^a	36 ^a	36 ^a
Low-Level						
Liquid	None	3,910 ^b (790,000 gal)	None	3,910 ^b (790,000 gal)	None	None
Solid	None	660	272 ^c	660	272 ^b	272 ^b
Mixed Low-Level						
Liquid	None	None	None	None	None	None
Solid	None	6	6	6	6	6
Hazardous						
Liquid	Included in solid	Included in solid	Included in solid	Included in solid	Included in solid	Included in solid
Solid	850	35	35	35	35	35
Nonhazardous (Sanitary)						
Liquid	74,300 (15,000,000 gal)	248,000 (50,000,000 gal)	248,000 (50,000,000 gal)	14,100,000 (2,850,000,000 gal)	14,100,000 (2,850,000,000 gal)	14,100,000 (2,850,000,000 gal)
Solid	10,000	4,200	1,400 ^d	4,200	1,400 ^d	1,400 ^d
Nonhazardous (Other)						
Liquid	2,480 ^e (500,000 gal)	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary
Solid	Included in sanitary	3,500 ^f	None	3,500 ^f	None	None

^a Residual heavy metal content in spent nuclear fuel is 150,000 lb (68 metric tons).^b Liquid LLW is treated with the remaining LLW sludge being solidified.^c Assumes a 100:1 wastewater/sludge ratio in the treatment of liquid LLW, followed by 2:1 increase in volume from solidification of sludge. Assumes compaction factor of 3:1 for compactible solids.^d Assumes overall compaction factor of 3:1.^e Does not include groundwater dewatering, if required.^f Recyclable wastes.

Source: DOE 1995f.

A.2.1.4 Accelerator Production of Tritium

Mission. The primary mission of the APT facility would be to provide the tritium supply functions performed by DOE, as well as waste treatment functions related to APT operations.

Assumptions. The assumptions used in the design of this facility are listed in section A.2.

General Functions and Layout. APT would use a high-intensity beam of energetic protons produced by a linear accelerator to strike a heavy metal target. The interaction of the protons with the target material would generate a shower of neutrons which would be absorbed by surrounding helium-3 or lithium-6 atoms to produce tritium. The APT construction approach would be to build it in two phases with the first phase able to provide the steady-state tritium requirement and the second phase able to provide the baseline requirement. There are two different target designs (helium-3 and spallation-induced lithium conversion) under consideration for the baseline case which would each be based on a centrally located spallation neutron source (high Z material). The first phase of the APT would use only the helium-3 target design.

The APT facility would consist of the following components: linear accelerator, beam transport and switchyard, beam stop, target area, secondary cooling, electric substations, emergency power, support, waste treatment, radioactive waste processing, and new target inspection and storage. Figure A.2.1.4-1 is a functional diagram of the APT facility, with the difference between phases noted, while figure A.2.1.4-2 depicts the APT facility site layout.

Component Facility Functions

Linear Accelerator. The linear accelerator would consist of a sequence of electromagnetically resonant cavities sustaining radio frequency electric fields that deliver energy to a continuous stream of proton bunches. The initial phase of the APT would use 300 megahertz radio frequency energy in the low energy region and 700 megahertz radio frequency energy in the high energy region to deliver 100 milliamperes of 1 billion electron volt protons to the target chamber. The full-size APT would add another injector leg and a funnel to combine its proton beam

with the other to deliver 200 milliamperes of 1 billion electron volt protons (or equivalent beam power at lower energies) to the target chamber.

Beam Transport and Switchyard. At the end of the accelerator, the beam would be deflected to one of two target/blanket assemblies or a full power beam stop in the target area by a beam transport and switchyard. This system would consist of bending, and focusing magnets and evacuated pipes through which the proton beam would travel. The system would also provide the correct expanded beam size and shape at the target, and switch the beam between target/blanket assemblies as required. Before the beam is directed onto the target, the beam would be sent to the full power beam stop to tune the accelerator.

Beam Stop. The beam stop is a device that would be used to stop the proton beam during accelerator tune-up, or to dump the beam when necessary to divert the beam from the target area without shutting down the accelerator. The beam stop would accept the full power beam for an unlimited time while passively radiating the deposited power to an actively cooled structure.

Target Area. The target area concepts under consideration are detailed in the description of processes section. The target chamber would be located in a subterranean structure to place the target at the same elevation as the accelerator beam line. A confinement system would envelop the target area and those spaces housing the primary cooling loop components, as well as the compartments in which spent target handling, disassembly, and preparation for shipment are conducted. Tritium extraction would be dependent on the target system selected and is also discussed in the description of processes section.

Secondary Cooling Facility. The secondary cooling facility would include cooling towers or cooling ponds for rejecting accelerator waste heat to the atmosphere. The major heat sources would include radio frequency power losses in the accelerator structure, heat produced in power supplies and klystrons, heat deposited in the target/blanket assembly by the proton beam, decay heat from the irradiated target, and heat produced in tritium extraction and target processing facilities.

Electric Substations. The electric substations would receive electric power from the commercial grid, convert it to the required voltages for various functions, and distribute it to the accelerator, target/blanket chamber, processing systems, and other onsite facilities.

Emergency Power. The emergency power facility would house diesel generators or gas turbines that would be used to provide short-term emergency power to support safety-related loads in the event of temporary failure of the offsite power supply.

Support Facilities. The administration facility would house administrative, technical support, and clerical staff. It would include staff offices, a cafeteria, medical facilities, data processing, and a records center. The operations and utilities facility would provide for operational control and monitoring of the accelerator, target/blanket assembly, tritium extraction (as required by the target design), and associated support and safety systems. It would also provide for operator training, including simulators, serve as the center for site safeguards and security, provide personnel monitoring and access control, and house the safety related batteries providing an uninterruptible power supply for critical subsystems. The maintenance facility would provide shop and service areas for maintaining all accelerator, target/blanket, and processing system components. It would also provide warehousing and materials handling for consumables and spare parts for these systems.

Waste Treatment Facility. The waste treatment facility would receive and treat all site-generated sanitary sewage for release to the environment in accordance with an NPDES permit.

Radioactive Waste Processing Facility. This facility would receive all solid, liquid, and gaseous radioactive waste for storage, treatment, and packaging for either release or disposal at an appropriate permanent waste disposal facility.

Water Treatment Facility. This facility would treat water to meet the required quality for the various plant cooling systems. The fire protection system

would tap off the facility water supply upstream of the water treatment facility.

New Target Inspection and Storage Facility. This facility would provide for the unloading, receipt, inspection and storage of new target/blanket assemblies fabricated offsite. The facility would also load packaged spent targets onto transport equipment for removal to the final disposal site.

Description of Processes

Accelerator Operation. The accelerator would operate in continuous wave mode, meaning that the cavities would be excited 100 percent of the time rather than part of the time as in a pulsed system. Several types of accelerating structure geometries would be used to couple radio frequency energy to the beam over different velocity ranges. At full energy, the protons would travel at approximately 0.9 times the speed of light. The radio frequency field in the accelerating structures would be generated by a series of 1 megawatt (MW) klystrons (high power electron tubes) distributed along the length of the accelerator. For most of its 0.75 mile length, the accelerator would be located in a sealed, concrete-lined tunnel buried under about 40 feet of earth. A similar length building on the surface would house the klystrons, power supplies, and controls.

The magnetic transport system would direct the proton beam from the end of the accelerator to the tritium production target/blanket assembly. When the beam is directed to one of the target assemblies, the other would be undergoing service or would be on standby. When the beam is not directed at a target, it would be directed to the full-power beam stop through the diagnostic beam channel used for tuning the accelerator. At the ends of the transport channels, the beam would be expanded to a large, rectangular, uniform current distribution form to match the power density requirements of the targets.

Multiple redundant sensors distributed throughout the accelerator and beam lines would act within extremely short time frames to determine if the beam were out of acceptable limits in terms of position, energy, size, intensity distribution, etc. Malfunctions or out of tolerance values for any of these devices would terminate the beam.

Heat transport loops would be needed for the target blanket system. The primary cooling loop would transport the heat generated in the target and blanket (separate cooling loops) to a secondary cooling loop. The secondary cooling loop would transfer heat through a heat exchanger system to the atmosphere.

Tritium Production. The APT tritium production process would be dependent on the choice of APT design and target assembly employed. Two target concepts currently under consideration for the full-size APT are: helium-3 and spallation-induced lithium conversion.

- **Helium-3**—The target chamber would house a low-pressure, low-temperature target/blanket assembly consisting of a water-cooled inconel beam entrance window followed by a neutron-producing target of tungsten as depicted in figure A.2.1.4-3. That target would be cooled by circulating heavy water moderator with circulating, contained helium-3. The assembly would have lead in a surrounding annular region to provide neutron multiplication and moderation. About 60 percent of the tritium would be produced in the blanket region of the system; the remainder would be produced in a separate helium-3 volume in the spallation target. The purpose of the second helium-3 gas region is to act as a decoupler to reduce absorption of neutrons back into the tungsten source region. Tritium would be continuously removed from both regions by taking a side stream of the circulating helium-3 gas into a nearby processing area.
- **Spallation-Induced Lithium Conversion**—The target area, depicted in figure A.2.1.4-4 would contain a target system consisting of a heavy water-cooled lead spallation target, and light water-cooled lithium-aluminum target separated from the accelerator by a beam entrance window. The assembly would operate at relatively low temperature and low pressure. High energy protons would induce spallation of the lead target, thereby generating neutrons. Heavy

water coolant would remove the heat of spallation and moderate the neutrons to thermal energy. The lithium-6 isotope within the light water-cooled lithium-aluminum target rods would capture the thermal neutrons and produce tritium.

Tritium Extraction. The extraction process would be dependent on the APT design and target concept employed.

- **Helium-3**—In this process, a small slipstream would be taken off the gas circulating through the heavy water source and blanket regions, and hydrogen and tritium would be extracted using a permeable membrane technique. The helium-3 would then be recirculated to the target area. The extracted hydrogen and tritium would be separated by cryogenic distillation. The tritium would be of very high purity. An area would be required for cooling and radiation shielding of spent tungsten removed from the target cavity. Remote handling apparatus would load packaged targets into shipping casks and onto rail or truck vehicles. Spent tungsten targets would go to existing waste management facilities for final disposal. The estimated volume of this material is small, typically on the order of a few cubic meters per year of operation. Figure A.2.1.4-5 provides the flow diagram for the helium-3 process.
- **Spallation-Induced Lithium Conversion**—Following irradiation, the targets would be removed and transported to the disassembly basin, where the target tubes would be allowed to cool for approximately 6 months so that short-lived isotopes could decay. After cooling, the target tubes would be washed within the shielded transport cask, placed in a crucible, inserted into a furnace, and heated to drive off the gases, including the tritium product. The gas stream from the furnace, mainly helium and hydrogen isotopes, including tritium, would pass through a diffusing process to separate the hydrogen isotopes from helium and

other impurities. This process would cycle the gas between two beds of treated diatomaceous earth used as a filter aid. One bed would be heated to drive off the gases; the other bed would be cooled to promote gas absorption. Figure A.2.1.4-6 depicts the flow diagram for the spallation-induced lithium conversion process.

Facility Utilities. Facility construction and operation utility requirements are shown in tables A.2.1.4-1 and A.2.1.4-2, respectively.

Chemicals Required. Table A.2.1.4-3 depicts chemical resources required during operations.

Personnel Requirements. Construction of the APT would have a peak employment of 2,760 construction workers. Approximately 6,380 worker years would be needed during the 5-year construction period. In the phased approach, the majority of civil engineering construction for both phases would be completed during initial construction. The upgrade from the first phase to the Full APT would involve installation of the equipment in the second injection line, the funnel, and additional radio frequency power systems. Operation of either APT facility would require 624 workers with 258 of these badged for radiation detection.

Transportation. Interfacility transfers would be made by rail or truck transport. Truck service would be needed for intrafacility movements. Helium would be received in bulk by rail and unloaded into cylinders for storage.

Waste Management. Solid and liquid nonhazardous wastes generated during construction would include concrete and steel construction waste materials and sanitary wastewater. The steel construction waste would be recycled as scrap material before completing construction. The remaining nonhazardous wastes generated during construction would be disposed of as part of the construction project by the contractor. Uncontaminated wastewater would be used for soil compaction and dust control, and excavated soil would be used for grading and site preparation. Wood, paper, and metal wastes would be shipped offsite to a commercial contractor for recycling. Hazardous wastes generated during con-

struction would consist of such materials as waste adhesives, oils, cleaning fluids, solvents, and coatings. Hazardous waste would be packaged in DOT-approved containers and shipped offsite to commercial RCRA-permitted treatment, storage, and disposal facilities. No radioactive waste would be generated during construction.

The facility design incorporates waste minimization and pollution prevention. Activities that generate radioactive and hazardous wastes would be segregated, where possible, to avoid the generation of mixed wastes. Where applicable, treatment to separate radioactive and nonradioactive components would be performed to reduce the volume of mixed wastes and provide for cost-effective disposal or recycling. To facilitate waste minimization, where possible, nonhazardous materials would be substituted for those materials which contribute to the generation of hazardous or mixed waste. Production processes would be configured with minimization of waste production given high priority. Material from the waste streams would be treated to facilitate disposal as nonhazardous wastes, where possible. Future D&D considerations have also been incorporated into the design.

Tables A.2.1.4-4 and A.2.1.4-5 present the estimated annual waste volumes from the Full APT facility for the two target designs during construction and operation. Table A.2.1.4-4 presents the estimated waste volumes for the Phased APT. All process and waste systems would be housed in enclosures designed to contain and allow recovery of tritium leaks. A gaseous waste system would recover residual tritium before releasing the waste to the atmosphere. Solid and liquid waste streams would be routed to the waste management system. Solid wastes would then be characterized and segregated into LLW, hazardous, and mixed wastes, then treated into a form suitable for disposal or storage within the facility. Liquid wastes would be treated onsite to reduce hazardous/toxic and radioactive elements before discharge or transport. All fire sprinkler water discharged in process areas would be contained and treated as process wastewater, when required.

Spent Nuclear Fuel. The APT facility would not generate any spent nuclear fuel.

Transuranic Waste. The APT facility would not generate any TRU waste.

Low-Level Waste. LLW would be generated by operations in the target and blanket area and the target tritium-extraction facility. The process stripper would remove any tritium from process streams; thus eliminating liquid LLW generation. The bulk of the solid LLW would be generated in the tritium extraction facility. Solid LLW from the accelerator would result from klystron and ion pump refurbishment and cooling system maintenance. LLW generated in the spallation-induced lithium conversion (or lithium-aluminum) target area would include treatment residues, spent resin filters, piping and pressure tubes, the window, and job control wastes. From the helium-3 target area solid LLW would include treatment residues, spent resins and filters, inconel, zircaloy, and job control wastes. The lithium-aluminum target tritium-extraction system would generate job control wastes, crucibles, spent lithium-aluminum melts, piping, valves, and filters. Solid LLW from the helium-3 target tritium extraction system would include job control wastes, piping, valves, and filters. Solid LLW would be compacted as appropriate and then disposed of in a suitable disposal facility.

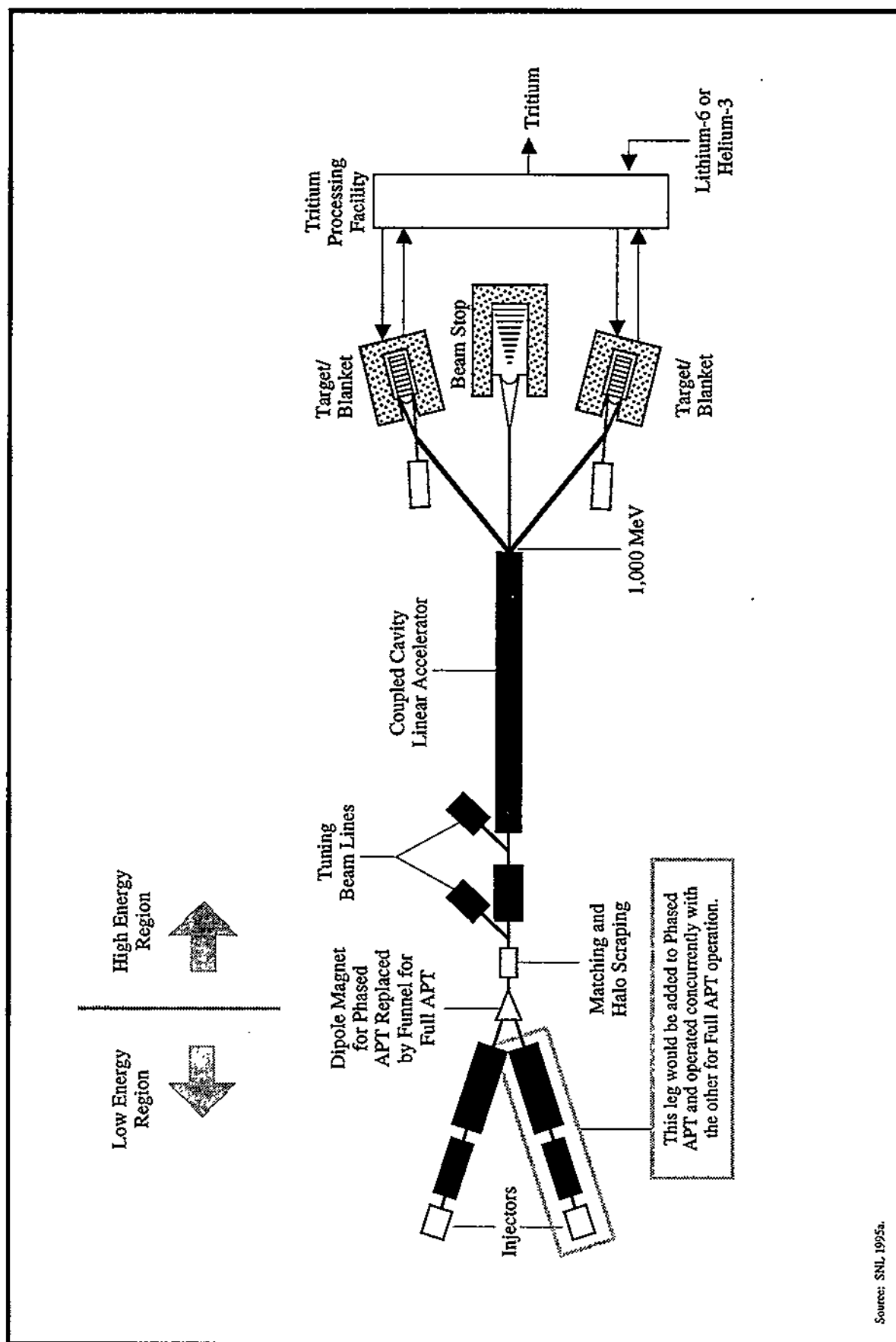
Mixed Low-Level Waste. No liquid mixed LLW would be generated from the APT facility. Solid mixed LLW from the accelerator would include solvent rags and discarded batteries. The lithium-aluminum target area would generate solvent rags, lead aluminum targets, discarded batteries, and paint while the tritium target extraction facility sources of mixed LLW would include contaminated batteries, aerosol cans, and spent solvents. After removal from the target area, the spent lead targets would be stored in pools for one year. In this time the activity would decrease from 10 to 20 million curies (Ci) to 100,000 Ci. The targets would then be processed for disposal as solid mixed LLW. Mixed LLW from the helium-3 target area would include discarded batteries and paint with the tritium target extraction facility generating contaminated batteries, aerosol cans, and spent solvents. Mixed waste would be processed in accordance with the site-specific

treatment plan that was developed to comply with the *Federal Facility Compliance Act* of 1992.

Hazardous Waste. Depending on the treatment technology selected, a small quantity (< 1 gal) of liquid hazardous wastes could be generated from the treatment of mixed LLW. Solid hazardous wastes would be generated from nonradioactive materials such as wipes contaminated with oils, lubricants, and cleaning solvents that are used for equipment outside the main processing units. After compaction, if appropriate, the solid hazardous wastes would be packaged in DOT-approved containers and sent to an onsite hazardous waste storage facility for staging prior to shipment to a commercial RCRA-permitted treatment, storage, and disposal facility using DOT-certified transporters.

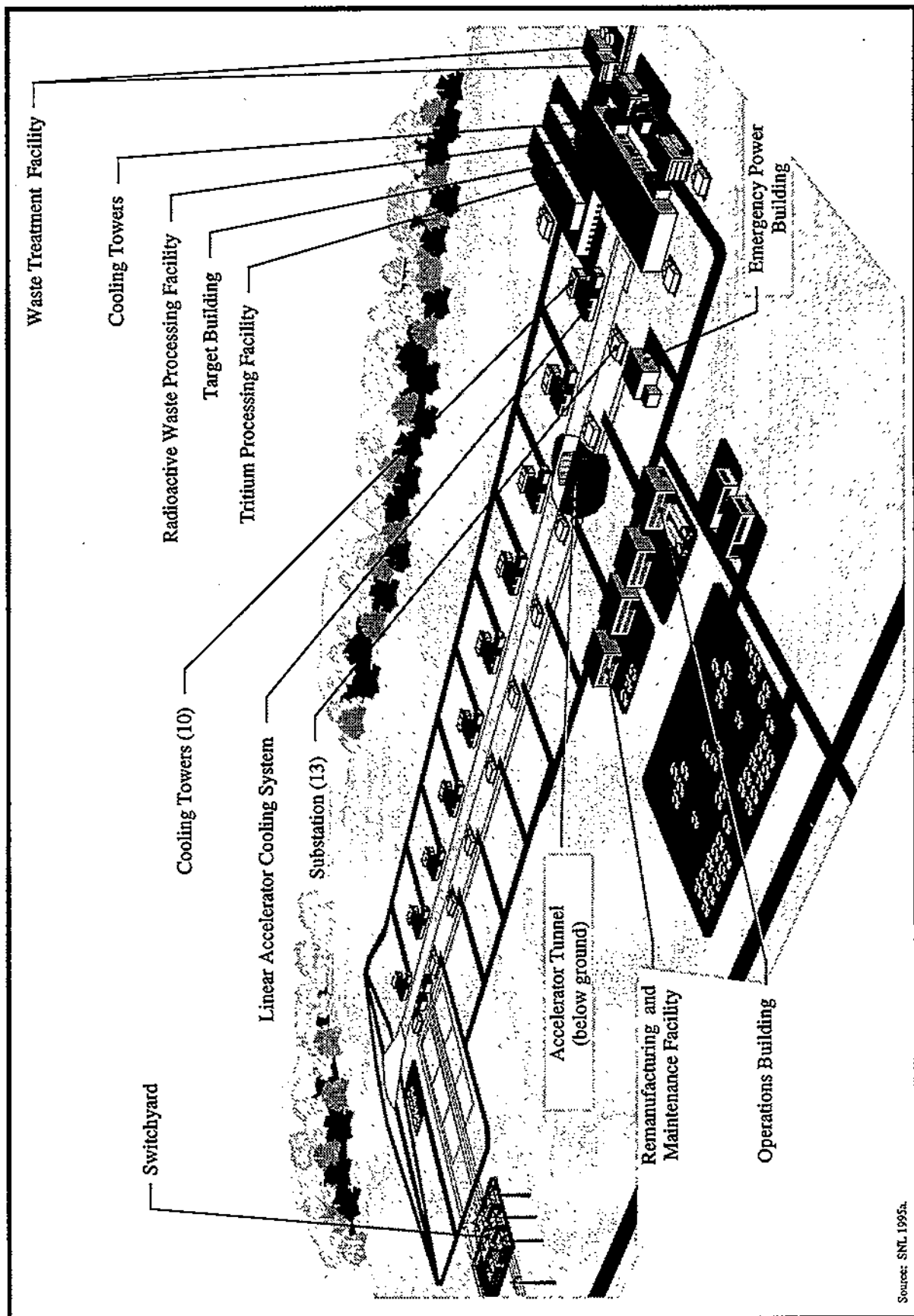
Nonhazardous Waste. Sewage wastewater would be treated in the waste treatment facility. Sewage wastewater would be kept separate from all industrial and process wastewaters and would normally contain no radioactive wastes from the facility. The sewage wastewater would be routinely monitored for radioactive contaminants. The sludge and other nonrecyclable solid sanitary and industrial wastes would be disposed of in a permitted landfill. The treated effluent would be discharged to the river through an NPDES outfall (wet site) or a natural drainage channel (dry site). Cooling tower blowdown would be treated and discharged to the river (wet site) or recycled for reuse (dry site). The treated effluent from the utility wastewater treatment would be discharged to the river through an NPDES outfall (wet site) or a natural drainage channel (dry site). All sludges would be disposed of in a permitted landfill.

The facility design includes stormwater retention facilities with the necessary NPDES monitoring equipment. Rainfall is collected separately and routed to the stormwater collection ponds and then sampled and analyzed before discharge to the natural drainage channels (dry site) or river (wet site). If the runoff is contaminated, it would be treated in the radioactive waste treatment system. Runoff outside the facility area would be discharged directly into the natural drainage channels or river.



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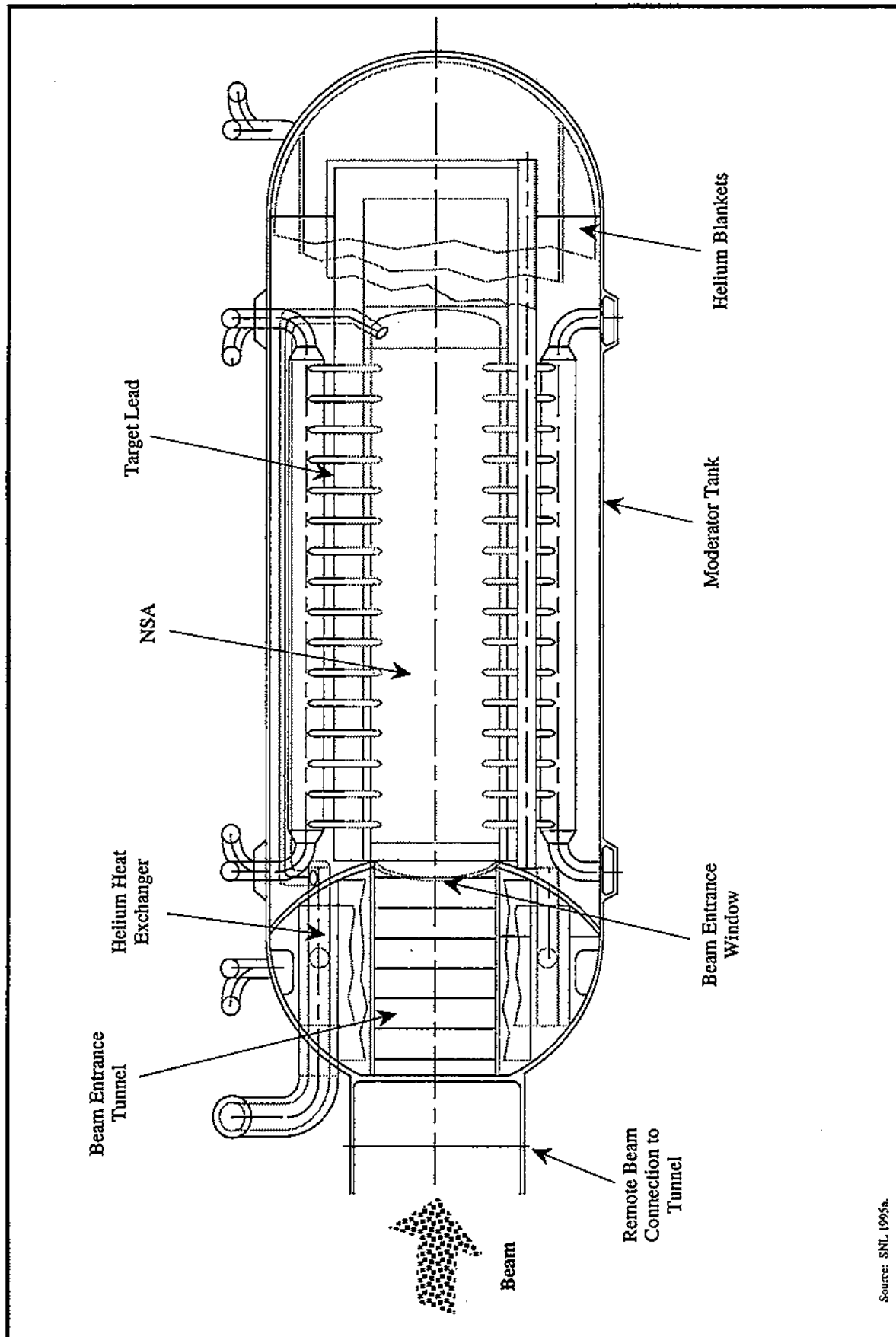
FIGURE A.2.1.4-1.—Accelerator Production of Tritium Facility Functional Layout.



Source: SNL 1995a.

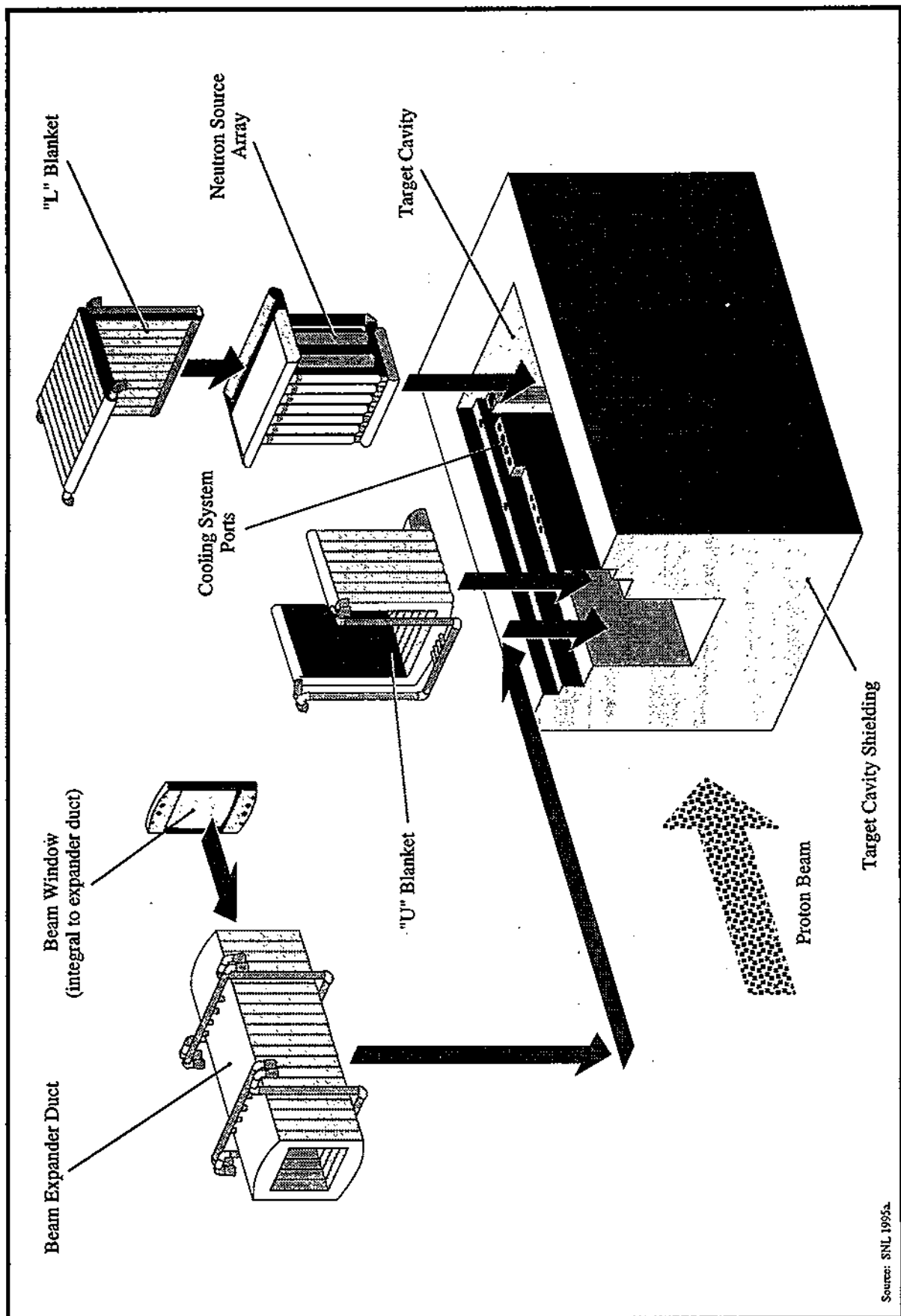
22968 App

FIGURE A.2.1.4-2.—Accelerator Production of Tritium Facility Site Layout (Typical).



2196

FIGURE A.2.1.4-3.—Accelerator Production of Tritium/Helium-3 Target System.



2335 App

Source: SNL 1995a.

FIGURE A.2.1.4-4.—Accelerator Production of Tritium/Spallation-Induced Lithium Conversion Target System (Exploded).

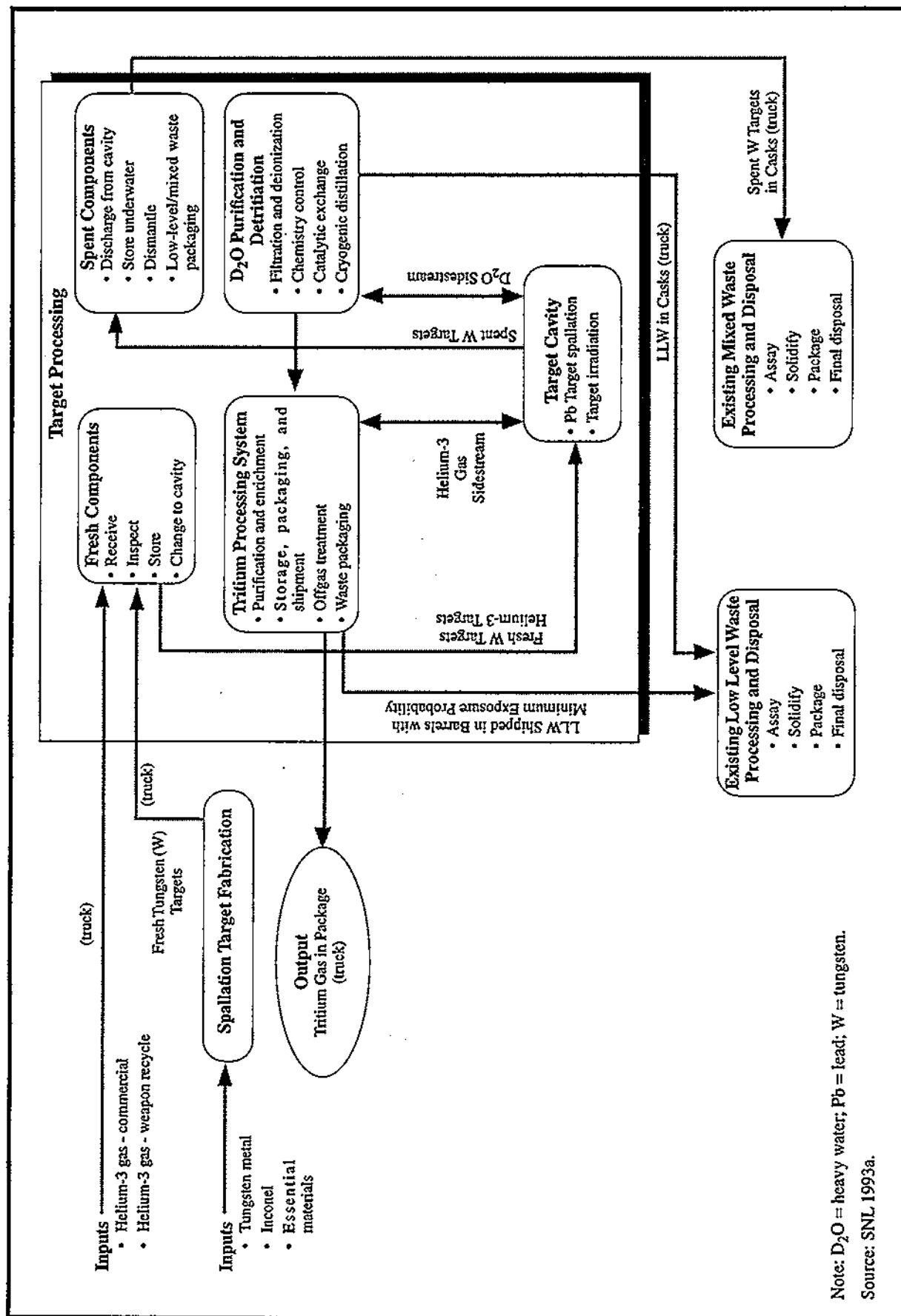


FIGURE A.2.1.4-5.—Flow Diagram for Accelerator Production of Tritium/Helium-3 Target.

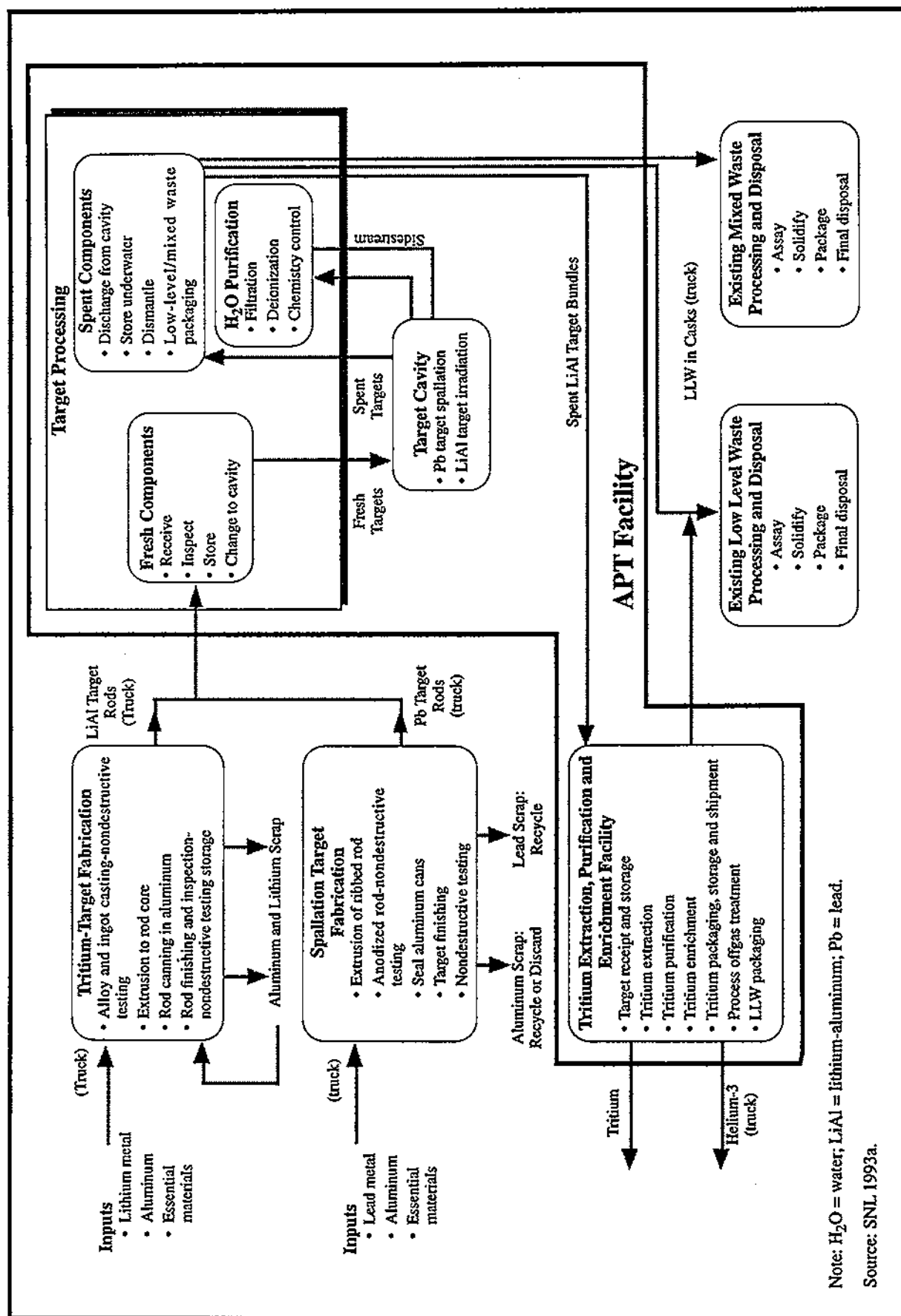


FIGURE A.2.1.4-6.—Flow Diagram for Accelerator Production of Tritium/Spallation-Induced Lithium Conversion Target.

TABLE A.2.1.4-1.—Accelerator Production of Tritium Construction Material/Resource Requirements

Material/ Resource	Consumption	
	Full	Phased
Electrical energy (MWh)	40,000	40,000
Concrete (yd ³)	275,000	275,000
Steel (tons)	61,495	55,820
Fuel (gal)	2,110,000	2,110,000
Water (gal)	41,700,000	41,700,000

Source: SNL 1995a.

TABLE A.2.1.4-2.—Accelerator Production of Tritium Operation Utility Requirements

Utility	Consumption	
	Full	Phased
Electrical Energy (MWh/yr)	3,740,000	2,400,000
Electrical Load (MWe)	550	355
Fuel		
Gas (ft ³ per year)	0	0
Liquid (GPY)	13,200	13,200
Water (MGY)	1,200	770

Source: SNL 1995a.

TABLE A.2.1.4-3.—Accelerator Production of Tritium Annual Chemical Requirements

Chemical	Quantity (tons)	
	Full	Phased
Aluminum	50	13.3
Uranium metal	0.4	0
Lithium metal	1.2	0
Stainless steel	32	7.1
Sodium hydroxide	0.22	0.14
Sulfuric acid	1,375	880

Source: SNL 1995a.

TABLE A.2.1.4-4.—Accelerator Production of Tritium (Helium-3 Target) Estimated Waste Volumes

Category	Annual Average Volume Generated From Construction (yd ³)	Annual Volume Generated From Operations (yd ³)	Dry Site		Wet Site	
			Annual Volume Effluent From Operations (yd ³)		Annual Volume Effluent From Operations (yd ³)	
Low-Level						
Liquid	None	None	None	None	None	None
Solid	None	72	57 ^a	57 ^a	57 ^a	57 ^a
Mixed Low-Level						
Liquid	None	None	None	None	None	None
Solid	None	3.7	3.1	3.1	3.1	3.1
Hazardous						
Liquid	Included in solid	None	0.0003 (0.06 gal)	0.0003 (0.06 gal)	0.0003 (0.06 gal)	0.0003 (0.06 gal)
Solid	13	1.2	1.2	1.2	1.2	1.2
Nonhazardous (Sanitary)						
Liquid	1,570 ^b (317,000 gal)	1,210,000 ^c (245,000,000 gal)	<1,000 (<200,000 gal)	<1,000 (<200,000 gal)	1,210,000 (245,000,000 gal)	1,210,000 (245,000,000 gal)
Solid	5,500	1,240	413 ^d	413 ^d	413 ^d	413 ^d
Nonhazardous (Other)						
Liquid	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary
Solid	Included in sanitary	None	Included in sanitary	Included in sanitary	None	None

^a Assumes compaction factor of 3:1 for personnel protection equipment compatible solids and 2:1 for metallics.

^b Does not include groundwater dewatering, if required.

^c At a dry site, the treated effluent from cooling tower blowdown and the sanitary wastewater treatment plant are recycled for reuse as cooling water makeup and other services after treatment.

^d Assumes overall compaction factor of 3:1.

Source: SNL 1995a.

TABLE A.2.1.4-5.—Accelerator Production of Tritium (Spallation-Induced Lithium Conversion Target) Estimated Waste Volumes

Category	Dry Site			Wet Site	
	Annual Average Volume Generated From Construction (yd ³)	Annual Volume Generated From Operations (yd ³)	Effluent From Operations (yd ³)	Annual Volume	
Low-Level					
Liquid	None	None	None	None	None
Solid	None	544	221 ^a	221 ^a	221 ^a
Mixed Low-Level					
Liquid	None	None	None	None	None
Solid	None	6.8	3.9	3.9	3.9
Hazardous					
Liquid	Included in solid	None	0.003 (0.6 gal)	0.003 (0.6 gal)	0.003 (0.6 gal)
Solid	13	2.5	2.5	2.5	2.5
Nonhazardous (Sanitary)					
Liquid	1,570 ^b (317,000 gal)	1,210,000 ^c (245,000,000 gal)	<1,000 (<200,000 gal)	1,210,000 (245,000,000 gal)	1,210,000 (245,000,000 gal)
Solid	5,500	1,240	413 ^d	413 ^d	413 ^d
Nonhazardous (Other)					
Liquid	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary
Solid	Included in sanitary	None	Included in sanitary	Included in sanitary	None

^a Assumes compaction factor of 3:1 for personnel protection equipment compactible solids and 2:1 for metallics.^b Does not include groundwater dewatering, if required.^c At a dry site, the treated effluent from cooling tower blowdown and the sanitary wastewater treatment plant are recycled for reuse as cooling water makeup and other services after treatment.^d Assumes overall compaction factor of 3:1.

Source: SNL 1995a.

TABLE A.2.1.4-6.—Phased Accelerator Production of Tritium (Helium-3 Target Only) Estimated Waste Volumes

Category	Annual Average Volume Generated From Construction (yd ³)	Dry Site		Wet Site	
		Annual Volume Generated From Operations (yd ³)	Effluent From Operations (yd ³)	Annual Volume Generated From Operations (yd ³)	Effluent From Operations (yd ³)
Low-Level					
Liquid	None	None	None	None	None
Solid	None	68	54 ^a	54 ^a	54 ^a
Mixed Low-Level					
Liquid	None	None	None	None	None
Solid	None	3	2.5	2.5	2.5
Hazardous					
Liquid	Included in solid	None	0.0003 (0.06 gal)	0.0003 (0.06 gal)	0.0003 (0.06 gal)
Solid	13	1.2	1.2	1.2	1.2
Nonhazardous (Sanitary)					
Liquid	1,570 ^b (317,000 gal)	789,000 ^c (159,000,000 gal)	<1,000 (<200,000 gal)	789,000 (159,000,000 gal)	789,000 (159,000,000 gal)
Solid	5,500	1,240	413 ^d	413 ^d	413 ^d
Nonhazardous (Other)					
Liquid	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary
Solid	Included in sanitary	None	Included in sanitary	None	None

^a Assumes compaction factor of 3:1 for personnel protection equipment compatible solids and 2:1 for metallics.^b Does not include groundwater dewatering, if required.^c At a dry site, the treated effluent from cooling tower blowdown and the sanitary wastewater treatment plant are recycled for reuse as cooling water makeup and other services after treatment.^d Assumes overall compaction factor of 3:1.

Source: SNL 1995a.

A.2.2 Tritium Recycling

Tritium recycling would either be collocated with the tritium supply facility or be located at SRS. If the tritium supply facility is collocated with a new recycling facility, there may be a potential for some efficiencies to be realized through the sharing of common facilities such as sanitary wastewater treatment. However, these efficiencies are not considered large enough to affect either a technology or site selection and thus, are not analyzed in this PEIS. At SRS, an upgrade of the existing recycling facilities would be implemented instead of constructing a new facility. The descriptions of the new recycling facilities, and the upgrades to the existing facilities at SRS, are in the following sections.

A.2.2.1 New Recycling Facility

Missions. The primary mission of the new tritium recycling facility would be to provide the full range of tritium processing, recycling, and packaging functions performed by DOE, as well as associated testing and waste management functions.

Assumptions. The assumptions used in the design of this facility are listed in section A.2.

General Functions and Layout. The tritium recycling facility would consist of two major buildings and associated support facilities as depicted in figure A.2.2.1-1. The tritium recycling building would house the systems that process inventories of tritium and tritium contaminated items along with the plant operations center.

The auxiliary building, the other major building, would house the nontritium functions as well as the emergency power diesel generators for the tritium recycling building. The plant support buildings would provide general services such as administration, cafeteria, fire protection, medical, environmental, safety, and health.

Component Facility Functions. Many modern nuclear weapons employ tritium gas or a mixture of tritium and deuterium gases, contained in reservoirs, to improve weapons performance. Radioactive decay reduces the reservoir tritium content, which means that stockpile reservoirs must be replaced periodically. The residual tritium from the returned

reservoirs would be recovered for recycle, and the empty reservoir would be reclaimed and reused if possible. At the tritium recycling facility, reservoirs would be subjected to stringent environmental and performance tests to their integrity under all service conditions. The facility also would be the source for tritium used for commercial applications and for fusion research and development.

Description of Processes. The tritium recycling facility processes are depicted in figure A.2.2.1-2. Tritium would be received in reservoirs returned from the field, or as virgin tritium from an extraction facility associated with a tritium supply facility. The reservoirs would be unpacked from their shipping containers and stored in a vault prior to being emptied.

The reservoirs would be emptied and the contained gases processed to separate the hydrogen isotopes from other gases, primarily helium-3 (a product of the radioactive decay of tritium). The hydrogen isotopes would be separated into tritium, deuterium, and protium (normal hydrogen). Tritium and deuterium would be used to prepare a specified isotopic mixture for the reservoirs. Protium would be discharged to the stack. The empty reservoirs would be reclaimed, if possible, and refilled. Reservoirs that could not be reclaimed would be handled as solid LLW. The helium-3 would be purified to remove any residual tritium and other contaminants prior to packaging as a by-product.

The reclaimed and/or new reservoirs would be filled with specific mixtures of gases. These gas mixtures could be obtained by using recovered gas of the proper specification, adding pure isotopes to the mix of recovered gases, or blending the pure isotopes. Once the reservoirs were filled, they would be sealed with a closure weld, trimmed, surface decontaminated, leak tested, inspected, marked, assayed for tritium content, and fitted with an explosively-actuated squib valve, if required. The reservoirs would then be placed in a storage vault until they were packaged and sent to the field for limited life component exchange in a weapon system.

A sampling of the newly-filled reservoirs would be placed in the life storage area for surveillance operations. As these reservoirs age, they would be examined and tested to confirm predicted behavior

and to ensure the integrity and function of the reservoirs in the field. Surveillance operations would include environmental testing, functional testing, calorimetry, flow testing, and burst testing. These tests would be performed to evaluate the behavior of the selected reservoirs (including reservoirs returned from the field or in life storage) under test conditions. The tritium recycling facility would also provide capabilities for metallurgical studies and gas sample composition analyses. The tritium recycling facility also would have the capability to fill containers with specified gas mixtures for commercial use and research applications.

Facility Utilities. Facility construction and operation utility requirements are shown in tables A.2.2.1-1 and A.2.2.1-1, respectively.

Chemicals Required. Table A.2.2.1-3 depicts chemical resources required during operation.

Personnel Requirements. Construction of the tritium recycling facility would have a peak employment of 335 construction workers. Approximately 992 worker years would be needed during the 4-year construction period. Operation requirements of the tritium recycling facility would be 910 workers total with 400 of these badged for radiation detection.

Transportation. Interfacility transfers would be made by DOE contract cargo carriers. Truck service would be needed for intrafacility transport.

Waste Management. The solid and liquid nonhazardous wastes generated during construction would include concrete and steel construction waste materials and sanitary wastewater. The steel construction waste would be recycled as scrap material before completing construction. The remaining nonhazardous wastes generated during construction would be disposed of as part of the construction project by the contractor. Uncontaminated wastewater would be used for soil compaction and dust control, and excavated soil would be used for grading and site preparation. Wood, paper, and metal wastes would be shipped offsite to a commercial contractor for recycling. Hazardous wastes such as waste adhesives, oils, and solvent rags would be packaged in DOT approved containers and shipped offsite to commercial RCRA-permitted treatment, storage, and

disposal facilities. No radioactive waste would be generated during construction.

The facility design considers and incorporates waste minimization and pollution prevention. The facility recovery system would provide the necessary equipment to recover, purify, and package helium-3, and to recover tritium from tritiated wastes generated within the facility, possible offsite sources, and the glove box inert atmospheres. The recovery system consists of strippers, tritiated aqueous recovery, tritium scrap recovery, and helium-3 recovery. Activities that generate radioactive and hazardous wastes would be segregated, where possible, to avoid the generation of mixed wastes. Where applicable, treatment to separate radioactive and nonradioactive components would be performed to reduce the volume of mixed wastes and provide for cost-effective disposal or recycle. After evacuating and flushing with argon, empty reservoirs would be reclaimed, if necessary, and refilled. To facilitate waste minimization, where possible, nonhazardous materials would be substituted for those materials that contribute to the generation of hazardous or mixed waste. Tritium recycling operations would be configured with minimization of waste production given high priority. Material from the waste streams would be treated to facilitate disposal as nonhazardous wastes, where possible. Future D&D considerations would also be incorporated into the design.

Table A.2.2.1-4 presents the estimated annual waste volumes from the tritium recycling facility during construction and operation. One can expect a significant reduction in waste generation once the facility is built and operational. Solid and liquid waste streams would be routed to the waste management system. Figure A.2.2.1-3 depicts the waste management system for the tritium recycling facility at a dry site, while figure A.2.2.1-4 illustrates the waste management system for a wet site. Solid wastes would be characterized and segregated into LLW, hazardous, and mixed wastes, then immobilized and packaged for disposal or storage within the facility. Liquid wastes would be treated onsite to reduce hazardous/toxic and radioactive elements before discharge or transport. All fire sprinkler water discharged in process areas during and after a fire would be contained, monitored, sampled, and if required, retained until disposed.

Spent Nuclear Fuel. The tritium recycling facility would not generate any spent nuclear fuel.

Transuranic Waste. The tritium recycling facility would not generate any TRU waste.

Low-Level Waste. Tritium-contaminated wastewater would be generated by hydraulic burst testing and by the strippers. The tritium-contaminated wastewater is treated in the tritium recovery system to recover the tritium. Strippers are designed to remove hydrogen isotopes, water vapor, and methane from the process waste streams and the glove box recirculating inert atmosphere.

Strippers consist of four types (process, primary, secondary, and purge) and would utilize a similar process to recover residual tritium from tritiated gases. The process stripper would be designed to remove hydrogen isotopes and water vapor from process waste streams by oxidizing elemental hydrogen isotopes and trapping the oxides on molecular sieves (Z-beds) prior to discharging to the stack. After the bed becomes saturated, it would be heated with the water vapor then being routed to tritium aqueous recovery to recover hydrogen isotopes.

The primary stripper would be designed to continuously process and recirculate the glove box nitrogen or argon atmosphere in order to maintain acceptable tritium, water vapor, and oxygen levels inside the glove box. The secondary stripper would have the same design as a standby unit to process nitrogen gas from glove boxes when a tritium leak occurs, and also to serve as a spare for the primary stripper. The purge stripper employs the same type of process used in the other strippers to remove hydrogen isotopes and water vapor from the glove box airlock gas prior to discharging to the stack. The purge stripper also processes the blowdown from the primary and secondary strippers.

Two primary tritiated aqueous recovery processes (reactive metal bed and electrolysis) would be utilized in the tritium recycling facility. It has been assumed that the reactive metal bed process would handle the stripper Z-bed tritiated water and the electrolysis process would handle the tritiated water from outside sources. Tritium scrap recovery would take tritiated solid wastes such as metals and pieces from

reservoir reclamation, metallography, and burst testing; reduce them in size; and then transfer them to a container which would be baked in a vacuum oven. The tritiated off-gas would be evacuated to a storage tank for accountability of tritium prior to transfer to the process stripper. Any pyrophoric materials would be oxidized to allow for chemical stability. The solid components would then be cooled in the oven and managed in accordance with the solid LLW procedures outlined below.

Solid LLW would consist of hydride beds, U-beds, Z-beds, stripper catalysts, retired process equipment, glove box tools wastes, process metal residues, unreclaimed reservoirs, and low-specific activity waste. The LLW solids are reduced in size, immobilized, stabilized, packaged, and staged in the Long-Term Waste Storage Building while awaiting shipment to a suitable LLW disposal facility.

Mixed Low-Level Waste. Liquid mixed LLW would originate from potentially-contaminated used compressor and glove box bubblers (sealpot) oil. Solid mixed LLW would include solvent rags and oil-contaminated materials with trace quantities of tritium. Mixed LLW would be stored in the RCRA-permitted Long-Term Storage Building onsite until treatment and disposal in accordance with the site-specific treatment plan that is being developed to comply with the *Federal Facility Compliance Act* of 1992.

Hazardous Waste. The cleaning solvents selected would be from a list of nonhalogenated solvents to the extent practicable. Solid hazardous wastes would be generated from nonradioactive materials such as solvent rags, containers with residual hazardous materials, and lead-acid batteries. After compaction, if appropriate, the solid hazardous wastes would be packaged in DOT-approved containers and sent to the Waste Management Building for staging prior to shipment to a commercial RCRA-permitted treatment, storage, and disposal facility using DOT-certified transporters.

Nonhazardous Waste. Sewage wastewater would be treated in the facility sanitary wastewater treatment facility. Sewage wastewater would be kept separate from all industrial and process wastewaters and normally contains no radioactive wastes from the facility. The sewage wastewater would be routinely

monitored for radioactive contaminants. The sludge would be disposed of in a permitted landfill. As illustrated in figure A.2.2.1-3, at the dry site the treated effluent would be recycled to the cooling tower and used as makeup, while figure A.2.2.1-4 shows the treated effluent at the wet site being discharged into the river through a permitted NPDES outfall. Process wastewater would be treated at the process wastewater treatment facility. The sludge would be disposed of in a permitted sanitary landfill and the water would be reclaimed.

The facility design includes stormwater retention ponds with the necessary NPDES monitoring equipment. Rainfall within the main facility area would be collected separately and routed to the stormwater collection ponds and then sampled and analyzed before discharge to the natural drainage channels (dry site) or river (wet site). If the runoff is contaminated, it would be treated in the process wastewater treating

system. Runoff from the site outside of the main facility area would be discharged directly into the natural drainage channels or river. As depicted in figure A.2.2.1-3, at a dry site, the utility wastewater treatment system collects blowdown from the steam system and tower cooling water system. The blowdown water would be filtered and treated by conventional water treatment methods. The treated effluent serves as makeup to the tower cooling water system. The reject water would be evaporated and the condensate would be used for boiler makeup. The concentrated watery solution would be sent to a spray drier and the dry solids would be disposed of in a permitted landfill. As shown in figure A.2.2.1-4, at a wet site, the blowdown from the cooling tower would be discharged after treatment directly into the river through an NPDES outfall. Solid industrial, clean-shredded metal, after sanitization and demilitarization, and trash are collected and sent to a permitted landfill.

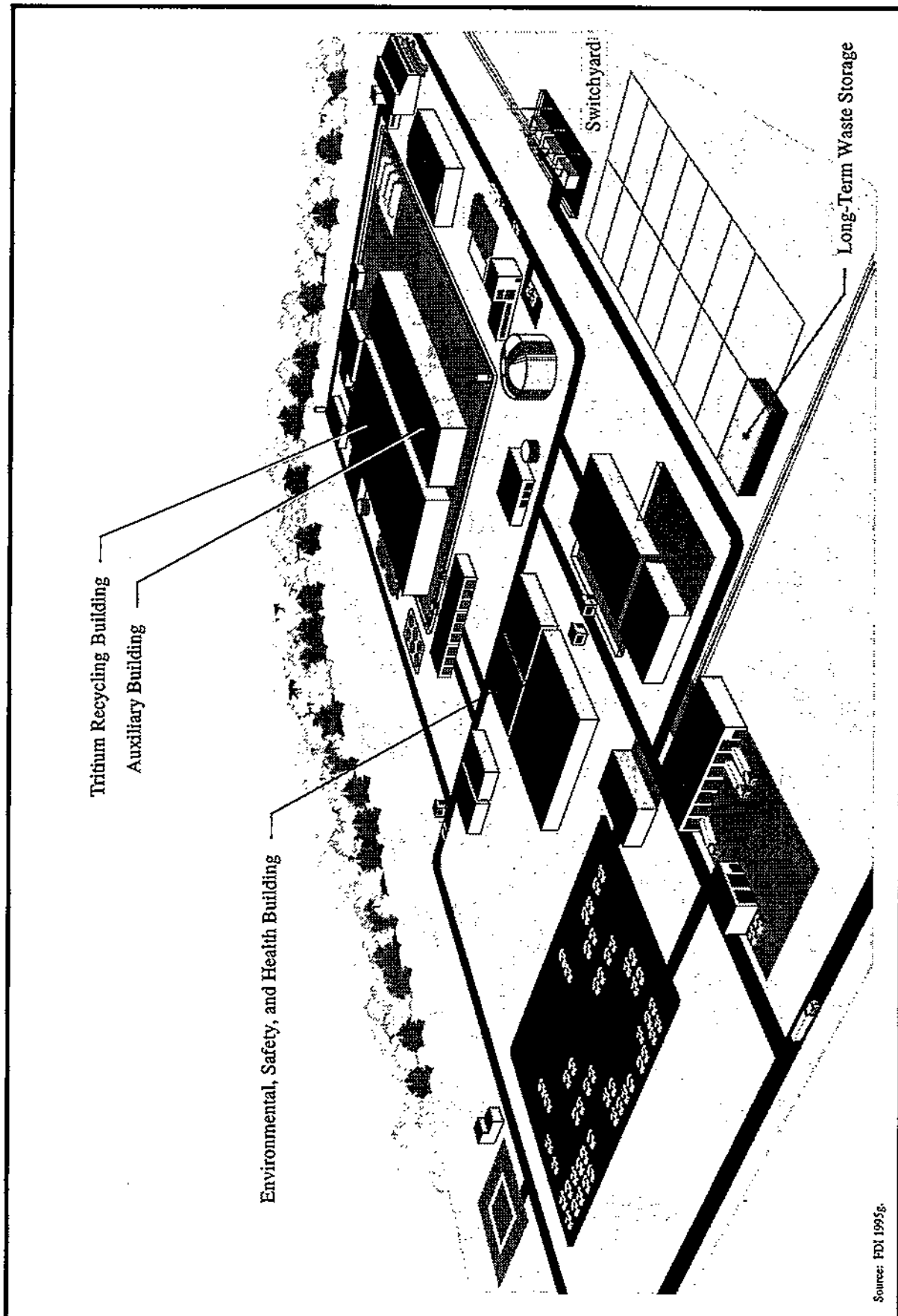


FIGURE A.2.2.1-1.—New Tritium Recycling Facility (Typical).



FIGURE A.2.2.1-2.—New Tritium Recycling Facility Processes.

Note: ICF = inertial confinement fusion; G = gas.
Source: DOE 1995g.

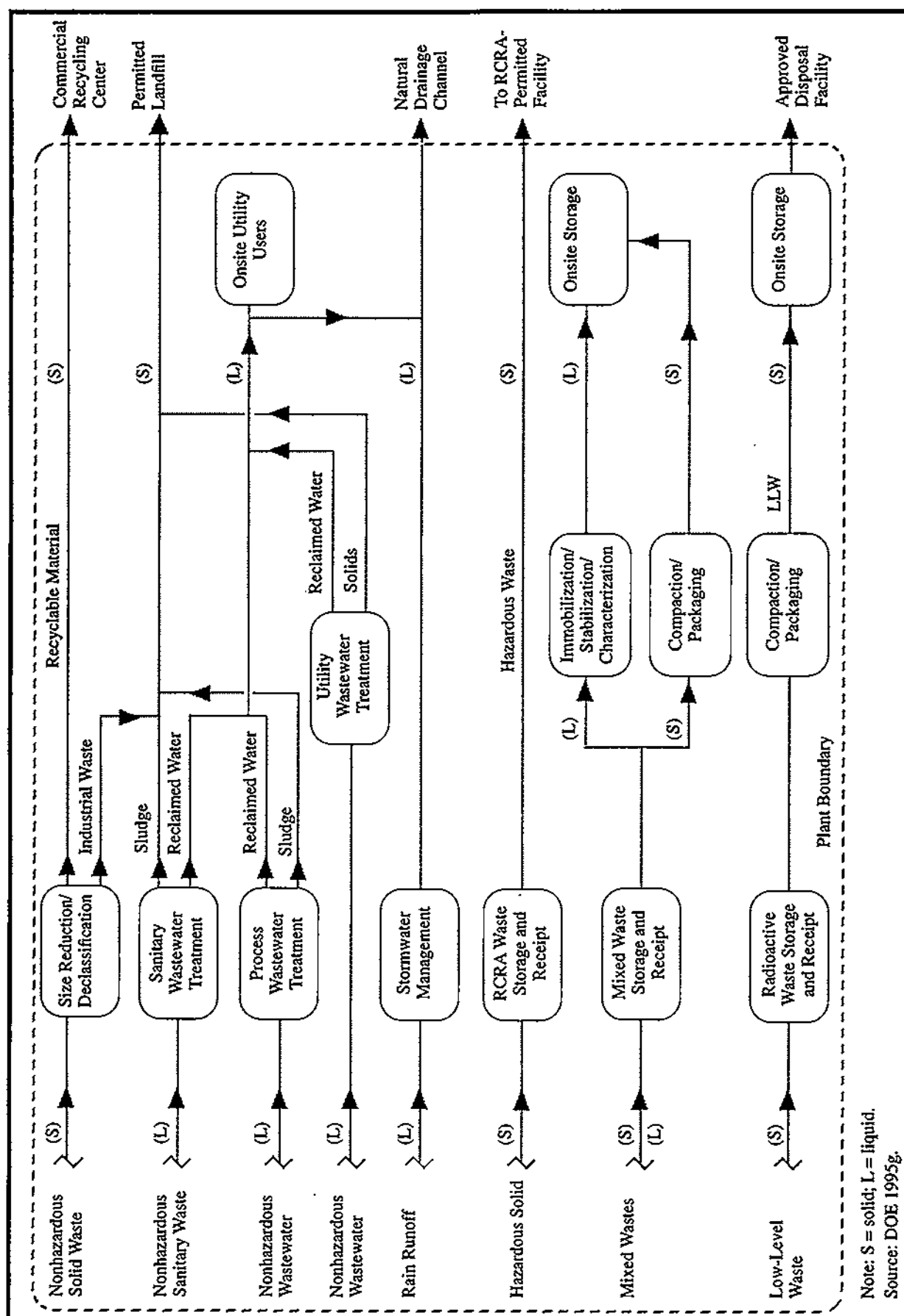


FIGURE A.2.2.1-3.—New Tritium Recycling Waste Management System Process (Dry Site).

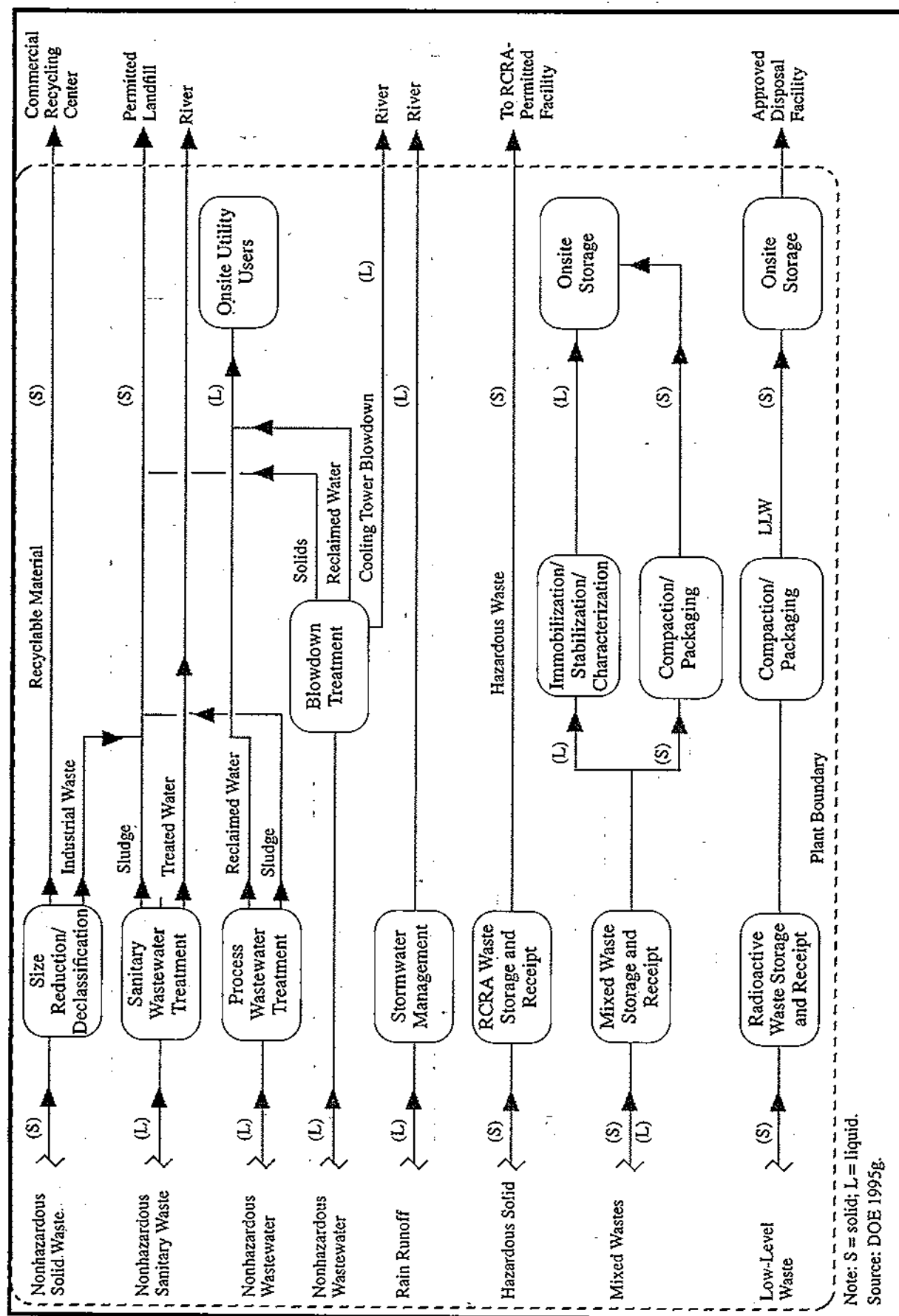


FIGURE A.2.2.1-4.—New Tritium Recycling Waste Management System Process (Wet Site).

TABLE A.2.2.1-1.—*New Tritium Recycling Facility Construction Material/Resource Requirements*

Material/Resources	Consumption
Electrical energy (MWh)	10,000
Concrete (yd ³)	32,000
Steel (tons)	5,600
Fuel (gal)	260,000
Water (gal)	6,100,000

Source: DOE 1995g.

TABLE A.2.2.1-2.—*New Tritium Recycling Facility Operation Utility Requirements*

Utility	Consumption
Electrical Energy (MWh/yr)	88,000
Electrical Load, (peak) (MWe)	16
Fuel	
Gas (ft ³ /yr)	7,000,000
Liquid (GPY)	50,000
Water (MGY)	
Wet site	37
Dry site	14

Source: DOE 1995g.

TABLE A.2.2.1-3.—*New Tritium Recycling Facility Annual Chemical Requirements*

Chemical	Quantity (lb)
Solid	
Adhesives, lubricants, and paints	360
Catalyst and molecular sieves	1,200
Depleted uranium (water decomposer)	2,800
Other ^a	1,700
Liquid	
Organic solvents ^b	3,700
Petroleum oils ^c	600
Water treatment chemicals ^d	9,800
Other ^e	3,700
Gaseous	
Argon	190,000
Helium	500
Nitrogen	3,500,000
Other ^f	8,900

^a Includes calcium nitrate, desiccant, magnesium metal, oxalic acid, Q-wax sealing compound, and silica gel.^b Includes ethyl alcohol, methanol, refrigerants, paint removers and thinners.^c Includes lubricating oils and seal oils.^d Includes aluminum sulfate, bentonite, chlorine, diethylaminoethanol, hydrazine, inorganic and organic phosphate, phosphoric acid, polyelectrolyte, polyphosphate, sodium sulfite and sulfuric acid. May be solid, liquid, or gas.^e Includes decontamination solutions.^f Includes acetylene, hydrogen, deuterium, carbon dioxide, oxygen, methane and methane-argon mixture.

Source: DOE 1995g.

TABLE A.2.2.1-4.—New Tritium Recycling Facility Estimated Waste Volumes

Category	Dry Site			Wet Site		
	Annual Average Volume Generated From Construction (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)	
Low-Level						
Liquid	None	None	None	None	None	
Solid	None	350	117 ^a	350	117 ^a	
Mixed Low-Level						
Liquid	None	0.03 (6 gal)	0.03 (6 gal)	0.03 (6 gal)	0.03 (6 gal)	
Solid	None	2	2	2	2	
Hazardous						
Liquid	Included in solid	None	None	None	None	
Solid	0.5	1	1	1	1	
Nonhazardous (Sanitary)						
Liquid	4,460 ^b (900,000 gal)	70,800 ^c (14,300,000 gal)	None ^e	119,000 (24,000,000 gal)	119,000 (24,000,000 gal)	
Solid	163 ^d	7,400	2,470 ^e	7,400	2,470 ^e	
Nonhazardous (Other)						
Liquid	Included in sanitary	Included in sanitary	None	Included in sanitary	Included in sanitary	
Solid	Included in sanitary	6,400 ^f	None	6,400 ^f	None	

^a Assumes overall compaction factor of 3:1.

^b Does not include groundwater dewatering, if required.

^c At a dry site, sanitary, utility, and process wastewaters would be recycled for reuse after treatment.

^d Includes 20 tons of steel construction waste material which would be recycled as scrap metal.

^e Assumes overall compaction factor of 3:1.

^f Recyclable wastes.

Source: DOE 1995g.

A.2.2.2 Tritium Recycling Facilities Upgrades at Savannah River Site

Missions. The primary mission of the upgraded tritium recycling facility would be to provide the full range of tritium processing, recycling, and packaging functions performed by DOE, as well as associated testing and waste management functions.

Assumptions. The assumptions used in the design of this facility are listed in section A.2.

General Functions and Layout. The tritium recycling facilities are centered on the new Replacement Tritium Facility (Building 233-H) and associated support facilities as depicted in figure A.2.2.2-1. The Replacement Tritium Facility was designed for gas handling operations (such as filling and emptying reservoirs), product separation, and enrichment activities. Support activities carried out in the following buildings are described by their assigned names: 232-H Tritium Extraction, Concentration, and Enrichment Facility; 232-1H Tritium Construction Pipe Shop; 232-H Maintenance Shop; 234-H Tritium Reservoir Finishing, Packaging, and Shipping Facility; 235-H Office Building; 236-H Burst Test Facility; 238-H Reservoir Reclamation Facility; 249-H Replacement Tritium Facility Support; and 720-H Central Alarm Station.

The proposed unconsolidated upgrade is designed to meet DOE Natural Phenomenon Hazard Requirements affecting buildings 232-H, 232-1H, 238-H, and 249-H. These upgrades would involve the addition of wall bracing and cross bracing to beams, strengthening some exterior walls, and reinforcing building frames. Building 232-H would also require an anchor for the service area roof slab and an upgrade of the radiation control and monitoring system. Building 234-H upgrades include highly invulnerable encased safes for reservoir storage to protect the tritium filled reservoirs during a high wind and earthquake.

A consolidated upgrade of SRS tritium recycling facilities is also possible. The consolidated upgrade entails the relocation of all tritium processing and handling functions from Building 232-H to buildings 233-H and 234-H in addition to the unconsolidated upgrade modifications. This upgrade would allow Building 232-H to be closed.

Component Facility Functions. Many modern nuclear weapons employ tritium gas contained in reservoirs to improve weapon performance. Radioactive decay reduces the reservoir tritium content, which means that stockpile reservoirs must be replaced periodically. The residual tritium from the returned reservoirs is recovered for recycle, and the empty reservoir reclaimed and reused if possible. Reservoirs are subjected to stringent environmental and performance tests to ensure their integrity under all service conditions. The facility also would be the source for tritium used for commercial applications and for fusion research and development.

Description of Processes. The tritium recycling facilities processes depicted in figure A.2.2.2-2 would be the same for both the unconsolidated and consolidated upgrades. Tritium would be received in reservoirs returned from the field, or as virgin tritium from an extraction facility associated with a tritium supply facility. The reservoirs would be unpacked from their shipping containers and stored in a vault prior to being emptied.

The reservoirs would be emptied and the contained gases processed to separate the hydrogen isotopes from other gases, primarily helium-3 (a product of the radioactive decay of tritium). The hydrogen isotopes would be separated into tritium, deuterium, and protium (normal hydrogen). Tritium and deuterium would be used to prepare the reservoirs. Protium would be discharged to the stack. The empty reservoirs would be reclaimed, if possible and refilled. Reservoirs that could not be reclaimed would be handled as solid LLW. The helium-3 would be purified to remove any residual tritium and other contaminants prior to packaging as a by-product.

The reclaimed and/or new reservoirs would be filled. The gas could be obtained by using recovered gas of the proper specification, adding pure isotopes to the mix of recovered gases, or blending the pure isotopes. Once the reservoirs have been filled, they would be sealed with a closure weld, trimmed, surface decontaminated, leak tested, inspected, marked, assayed for tritium content, and fitted with an explosively-actuated squib valve, if required. The reservoirs would then be placed in a storage vault until they were packaged and sent to the field for limited life component exchange in a weapon system.

A sampling of the newly-filled reservoirs would be placed in the life storage area for surveillance operations. As these reservoirs age, they would be examined and tested to confirm predicted behavior and to ensure the integrity and function of the reservoirs in the field. Surveillance operations would include environmental testing, functional testing, calorimetry, flow testing, and burst testing. These tests would be performed to evaluate the behavior of the selected reservoirs (including reservoirs returned from the field or in life storage) under test conditions. The tritium recycling facilities would also provide capabilities for metallurgical studies and gas sample composition analyses. The tritium recycling facilities would have the capability to fill containers with specified gas mixtures for commercial use and research applications.

Facility Utilities. Facility construction and operation utility requirements are shown in tables A.2.2.2-1 and A.2.2.2-2, respectively.

Chemicals Required. Table A.2.2.2-3 depicts the chemical resources required during operation.

Personnel Requirements. Upgrade of the tritium recycling facilities would have a peak employment of 26 construction workers for the unconsolidated upgrade and 36 workers for the consolidated upgrade. Approximately 62 worker years would be needed for the unconsolidated upgrade and 91 worker years for the consolidated upgrade during the 3-year construction period. Operation under the unconsolidated upgrade would require 970 workers of which 400 workers would be badged. The consolidated upgrade would require 910 workers of which 400 would be badged.

Transportation. Interfacility transfers would be made by DOE contract cargo carriers. Truck service would be needed for intrafacility transport.

Waste Management. The solid and liquid nonhazardous wastes generated during construction would include concrete and steel construction waste materials and sanitary wastewater. The steel construction waste would be recycled as scrap material before completing construction. The remaining nonhazardous wastes generated during construction would be disposed of as part of the construction project by the contractor. Wood, paper, and metal

wastes would be shipped offsite to a commercial contractor for recycling. Hazardous wastes generated during construction would consist of such materials as waste adhesives, oils, cleaning fluids, solvents, and coating. Hazardous waste would be packaged in DOT-approved containers and shipped offsite to commercial RCRA-permitted treatment, storage, and disposal facilities. No radioactive waste would be generated during construction.

The upgrade design considers and incorporates waste minimization and pollution prevention. The recovery system would provide the necessary equipment to recover, purify, and package helium-3, and to recover tritium from tritiated wastes generated within the facility, possible offsite sources, and the glovebox inert atmospheres. The recovery system consists of strippers, Z-bed recovery, tritium scrap recovery, and helium-3 recovery. Activities that generate radioactive and hazardous wastes would be segregated, where possible, to avoid the generation of mixed wastes. Where applicable, treatment to separate radioactive and nonradioactive components would be performed to reduce the volume of mixed wastes and provide for cost-effective disposal or recycle. After evacuating and flushing with argon, empty reservoirs would be reclaimed, if necessary, and refilled. To facilitate waste minimization, where possible, nonhazardous materials would be substituted for those materials that contribute to the generation of hazardous or mixed waste. Tritium recycling operations would be configured with minimization of waste production given high priority. Material from the waste streams would be treated to facilitate disposal as nonhazardous wastes, where possible. Future decontamination and decommissioning considerations have also been incorporated into the design.

Table A.2.2.2-4 presents the estimated annual waste volumes from the upgraded tritium recycling facilities at SRS during construction and operation. One can expect a reduction in waste generation and effluents once the facility is upgraded. As depicted in figure A.2.2.2-2, solid and liquid waste streams would be routed to the waste management system. Solid wastes would be characterized and segregated into LLW, hazardous, and mixed wastes, then immobilized and packaged for disposal. Liquid wastes would be neutralized, precipitated, and volume reduced via evaporation. The sludge would be

immobilized and packaged for disposal. All fire sprinkler water discharged in process areas during and after a fire would be contained, monitored, sampled, and, if required, retained until it could be disposed of.

Spent Nuclear Fuel. The upgraded tritium recycling facilities would not generate any spent nuclear fuel.

Transuranic Waste. The upgraded tritium recycling facilities would not generate any TRU waste.

Low-Level Waste. Liquid LLW would be generated by hydraulic burst testing and by the strippers; however, the tritium is recovered by Z-bed recovery. Thus, there is no solidification of any liquid LLW. Strippers would be designed to remove hydrogen isotopes, water vapor, and methane from the process waste streams and the glovebox recirculating inert atmosphere.

Strippers consist of four types (process, primary, secondary, and purge) and would utilize a similar process to recover residual tritium from tritiated gases. The process stripper would be designed to remove hydrogen isotopes and water vapor from process waste streams by oxidizing elemental hydrogen isotopes and trapping the oxides on molecular sieves (Z-beds) prior to discharging to the stack. After the bed becomes saturated, it would be heated and the water vapor then routed to tritium aqueous recovery to recover hydrogen isotopes. The primary stripper would be designed to continuously process and recirculate the glovebox nitrogen or argon atmosphere in order to maintain acceptable tritium, water vapor, and oxygen levels inside the glovebox. The secondary stripper would have the same design as a standby unit to process nitrogen gas from gloveboxes when a tritium leak occurs, and also to serve as a spare for the primary stripper. The purge stripper employs the same type of process used in the other strippers to remove hydrogen isotopes and water vapor from the glovebox airlock gas prior to discharging to the stack. The purge stripper also processes the blowdown from the primary and secondary strippers.

Tritium scrap recovery would take tritiated solid wastes such as metals and pieces from reservoir reclamation, metallography, and burst testing; reduce them in size; and then transfer them to a container

that would be baked in a vacuum oven. The tritiated off-gas would be evacuated to a storage tank for accountability of tritium prior to transfer to the process stripper. Any pyrophoric materials would be oxidized to promote chemical stability. The solid components would then be cooled in the oven and managed in accordance with the solid LLW procedures outlined below.

Solid LLW would consist of hydride beds, U-bed cartridges, Z-beds, stripper catalysts, retired process equipment, glovebox tools wastes, process metal residues, unreclaimed (empty) reservoirs, and low-specific activity waste. The LLW solids would be reduced in size, immobilized, stabilized, packaged, and then disposed of at one of the E-Area LLW disposal units.

Hazardous Waste. Solid hazardous wastes would be generated from nonradioactive materials such as solvent rags, containers with residual hazardous materials, and lead-acid batteries. After compaction, if appropriate, the solid hazardous wastes would be packaged in DOT-approved containers and sent to an onsite/offsite RCRA-permitted treatment, storage, and disposal facility. DOT-certified transporters would be used for any offsite shipments.

Mixed Low-Level Waste. Liquid mixed LLW would originate from potentially-contaminated used compressor and glovebox bubblers (sealpot) oil. Solid mixed LLW would include solvent rags and oil-contaminated materials with trace quantities of tritium. Mixed LLW would be stored in the RCRA-permitted facility onsite until the permanent disposal method could be determined. The overall management of mixed LLW would be in accordance with the Savannah River Site Treatment Plan, which is currently being developed to comply with the *Federal Facility Compliance Act of 1992*.

Nonhazardous Waste. Sewage wastewater would be treated at the onsite Sewage Treatment Plant Number 2 (607-H). Sewage wastewater would be kept separate from all industrial and process wastewaters and normally contains no radioactive wastes from the module. The sewage wastewater would be routinely monitored for radioactive contaminants. The sludge would be disposed of in a permitted landfill. As illustrated in figure A.2.2.2-3, the treated effluent would be discharged through a permitted

NPDES outfall. Industrial wastewater would be treated and discharged through a permitted NPDES outfall. The sludge would be disposed of in a permitted sanitary landfill. Solid industrial, clean-shredded metal, after sanitization and demilitarization, and trash would be collected and sent to a permitted landfill. As shown in figure A.2.2.2-2 the blowdown from the cooling tower and process wastewater would be discharged after treatment directly into the river through an NPDES outfall.

The upgrade design includes stormwater retention facilities with the necessary NPDES monitoring equipment. Rainfall within the facilities area would be collected separately and routed to the stormwater collection ponds and then sampled and analyzed before discharge into the river. If the runoff is contaminated, it would be treated in the process water treating system. Runoff from outside the facilities area would be discharged directly into the river.

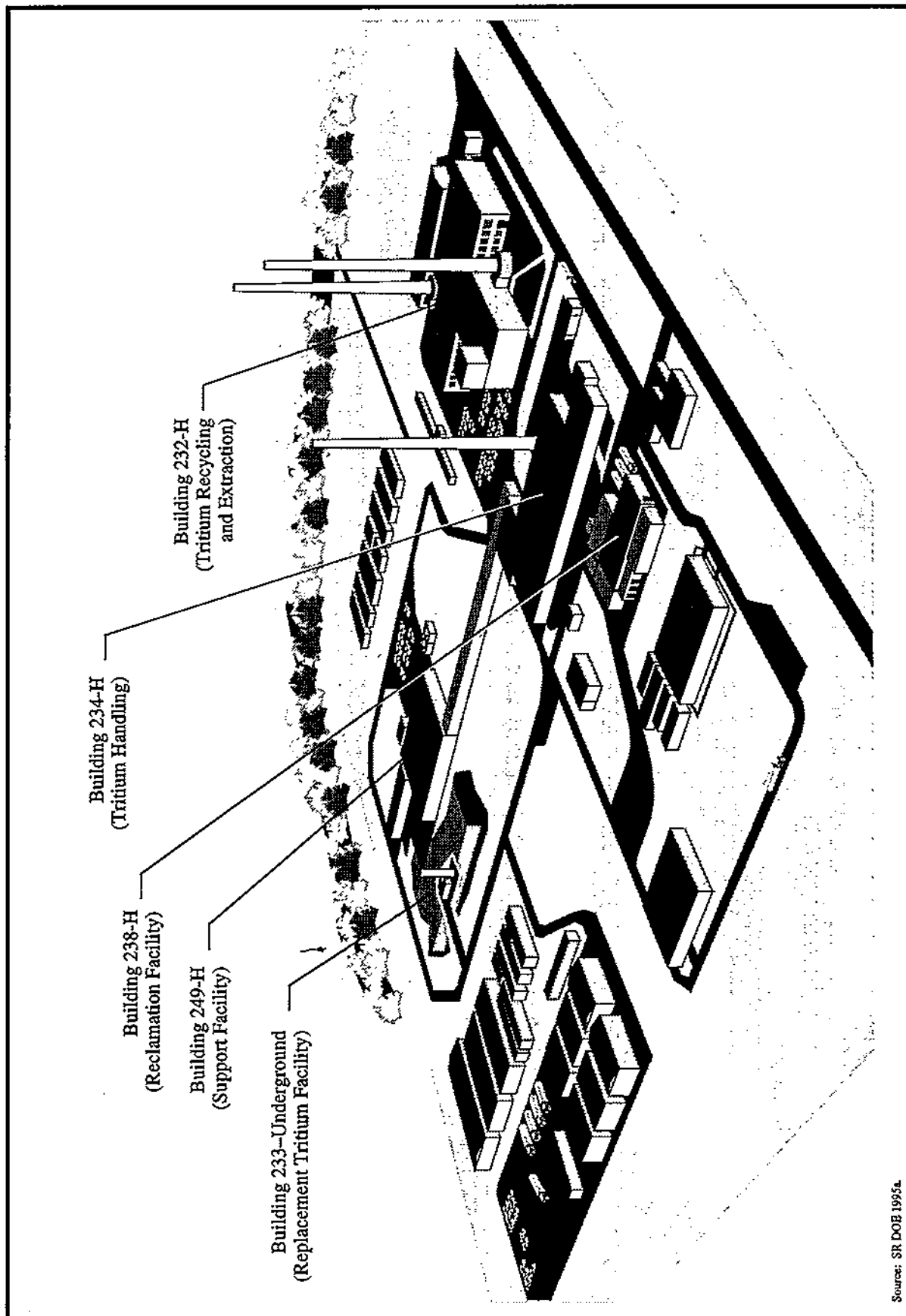


FIGURE A.2.2.2-1.—Tritium Recycling Facilities Upgrades at Savannah River Site (Generalized).



FIGURE A.2.2.2-2.—Upgraded Tritium Recycling Facilities Processes.

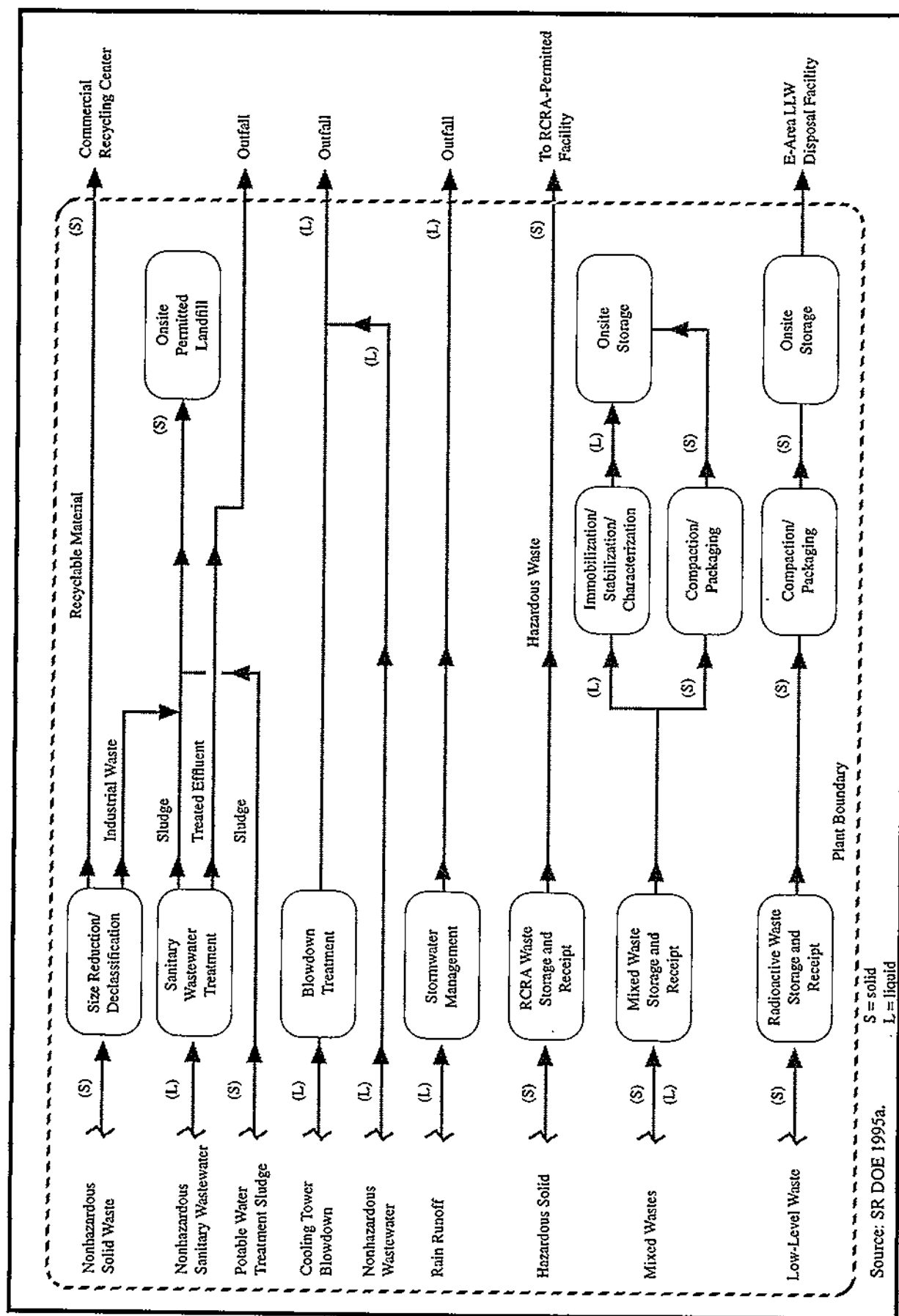


FIGURE A.2.2.2-3.—Upgraded Tritium Recycling Facilities Waste Management System.

TABLE A.2.2.2-1.—Upgraded Tritium Recycling Facilities Construction Material/Resource Requirements

Material/Resources	Consumption	
	Unconsolidated Upgrade	Consolidated Upgrade
Electrical energy (MWh)	2,000	2,000
Concrete (yd ³)	1,900	2,100
Steel (tons)	210	240
Fuel (gal)	16,000	17,000
Water (gal)	130,000	140,000

Source: SR DOE 1995a.

TABLE A.2.2.2-2.—Upgraded Tritium Recycling Facilities Operation Utility Requirements

Utility	Consumption	
	Unconsolidated Upgrade	Consolidated Upgrade
Electrical energy (MWh/yr)	24,000	24,000
Electrical load (MWe)	3	3
Coal (tons)	5,200	5,200
Fuel, liquid (GPY)	60,000	56,000
Water (GPY)	51,000,000	51,000,000

Source: SR DOE 1995a.

TABLE A.2.2.2-3.—Upgraded Tritium Recycling Facilities Annual Chemical Requirements

Chemical	Quantity (lb)	
	Unconsolidated Upgrade	Consolidated Upgrade
Solid		
Adhesives, lubricants and paints	330	330
Catalyst and molecular sieves	800	800
Depleted uranium (water decomposer)	1,500	1,900
Other solid chemicals ^a	1,500	1,500
Liquid		
Water treatment chemicals ^b	43,000	39,000
Petroleum oils ^c	550	550
Organic solvents ^d	3,400	3,400
Other liquid chemicals ^e	3,400	3,400
Gaseous		
Nitrogen	2,700,000	2,800,000
Argon	170,000	170,000
Helium	450	450
Other gaseous chemicals ^f	8,100	8,100

^a Includes calcium nitrate, desiccant, magnesium metal, oxalic acid, Q-wax sealing compound and silica gel.

^b Includes aluminum sulfate, bentonite, chlorine, diethylaminoethanol, hydrazine, inorganic phosphate, organic phosphate, phosphoric acid, polyelectrolyte, polyphosphate, sodium sulfite and sulfuric acid. May be solid, liquid, or gaseous.

^c Includes lubricating oils and seal oils.

^d Includes ethyl alcohol, methanol, refrigerants, paint removers and thinners.

^e Includes decontamination solutions.

^f Includes acetylene, hydrogen, deuterium, carbon dioxide, oxygen, methane, methane-argon mixture, and methane-argon-hydrogen mixture.

Source: SR DOE 1995a.

TABLE A.2.2.2-4.—Upgraded Tritium Recycling Facilities Estimated Waste Volumes

Category	Unconsolidated			Consolidated		
	Annual Average Volume Generated From Construction (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)	Annual Average Volume Generated From Construction (yd ³)	Annual Volume Generated From Operations (yd ³)	Annual Volume Effluent From Operations (yd ³)
Low-Level Waste						
Liquid	None	None	None	None	None	None
Solid	None	350	117 ^a	None	350	117 ^a
Mixed Low-Level Waste						
Liquid	None	0.03 (6 gal)	0.03 (6 gal)	None	0.03 (6 gal)	0.03 (6 gal)
Solid	None	2	2	None	2	2
Hazardous Waste						
Liquid	Included in solid	None	None	Included in solid	None	None
Solid	<0.3	1	1	<0.3	1	1
Nonhazardous Waste (Sanitary)						
Liquid	149 ^b (30,000 gal)	158,000 (32,000,000 gal)	158,000 (32,000,000 gal)	182 ^b (36,700 gal)	153,000 (31,000,000 gal)	153,000 (31,000,000 gal)
Solid	14 ^c	7,800	2,600 ^d	15 ^c	7,400	2,470 ^e
Nonhazardous Waste (Other)						
Liquid	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary	Included in sanitary
Solid	Included in sanitary	6,800 ^f	None	Included in sanitary	6,400 ^f	None

^a Assumes overall compaction factor of 3:1.^b Does not include groundwater dewatering, if required.^c Includes 1 ton of steel construction waste material which would be recycled as scrap metal.^d Assumes overall compaction factor of 3:1.^e Includes 1.3 tons of steel construction waste material which would be recycled as scrap metal.^f Recyclable wastes.

Source: SR DOE 1995a.

A.3 TRITIUM SUPPLY TECHNOLOGY OPTIONS

Light water reactors have undergone continual design improvements because they are used by the commercial power industry and the ALWR designs presented in this PEIS incorporate these improvements. Potential technological refinements to the MHTGR and HWR technologies that differ from those evaluated in this PEIS are provided below. This section also discusses the feasibility of using the tritium supply technologies to burn plutonium.

A.3.1 Technology Innovations

A.3.1.1 Gas Turbine Modular Helium Reactor

The initial MHTGR design for DOE's New Production Reactor Program was a 350 MWt steam cycle plant. The 600 MWt Gas Turbine Modular Helium Reactor represents a different technology, in which the primary helium coolant drives a turbine generator through a gas-compression/gas-expansion, heating/cooling cycle without a phase change. This represents a departure from the conventional steam cycle used in the 350 MWt design, in which steam, produced in the steam generator of the secondary heat exchanger, is used to drive the main turbine generator. In this respect, the Gas Turbine Modular Helium Reactor can be compared to a boiling water reactor in that they are both direct-cycle plant designs. The exception is that the Gas Turbine Modular Helium Reactor uses helium in a single phase for cooling and for driving the turbine. This gas turbine design achieves higher efficiency and reduces the design complexity by eliminating the feedwater and steam systems in the smaller MHTGR plant. The operating conditions of the 600 MWt design plant are elevated above those of the 350 MWt design. The higher operating temperatures, especially the hot helium (core outlet) temperature, provide a further increase in net plant efficiency over the 350 MWt design. Where three 350 MWt modules are considered necessary to meet the current tritium production baseline goal in this PEIS, only two 600 MWt modules would be needed.

Single Medium System. Hot helium exits the reactor core, flows through the center hot duct within the cross vessel, and expands through the turbine. The turbine directly drives the electrical generator, the low pressure compressor, and the high pressure

compressor. Helium exits the turbine and flows through the high efficiency plate-fin recuperator to return as much energy as possible to the cycle, then finally flows through the precooler to reject heat to the ultimate heat sink. Cold helium enters the inter-cooler compressor and passes through the recuperator. The helium then flows from the recuperator exit, through the outer annulus within the cross vessel, past the reactor vessel walls for vessel cooling, and finally down through the core to complete the loop.

Reactor Module. The reactor module arrangement of the 600 MWt design is similar to that of the 350 MWt design. The steam generator vessel of the 350 MWt design is replaced with a slightly larger diameter power conversion vessel in the 600 MWt design. The reactor and power conversion vessels are vertically positioned and connected by a coaxial cross vessel. The fuel particle and fuel element designs are identical, as are the lithium target particles, compacts, and assemblies.

Both reactor module designs refuel on the same schedule. Each design has a nominal 3-year residence time for the fuel, and one-third of the fuel blocks would be replaced annually. The target assemblies in all the fuel and reflector blocks would be replaced semiannually for the tritium supply mode.

Power Conversion Module. The power conversion vessel would contain the turbomachine, generator, recuperator, precooler, and intercooler. The basic function of this power conversion module is to convert heat energy to electrical energy and to provide the motive force for the helium primary coolant. A significant feature of the 600 MWt design turbomachine assembly is that the turbine, the two compressors, and the submerged generator would all be mounted on a single, vertical shaft. This would enable using a vertical power conversion vessel, be the most space efficient, and allow the removal of the turbomachine by the reactor building crane. Using a generator that is submerged within the helium primary coolant would eliminate the need for rotating shaft penetrations of the primary pressure boundary. Also, the turbomachine assembly would incorporate an active magnetic thrust bearing and three to five magnetic journal bearings. With this noncontact type of bearing, no bearing lubricants or coolants would

be required, and bearing power losses would be minimal.

Recuperator. The recuperator is a helium-to-helium heat exchanger included in the 600 MWt design. This heat exchanger would recover energy from the helium exiting the turbine and would utilize that energy to preheat the compressed helium before it enters the reactor. This recovery process would assist in achieving a net plant efficiency of approximately 48 percent compared to approximately 38 percent for the 350 MWt steam cycle design.

Precooler and Intercooler. The precooler and intercooler heat exchangers would be included in the power conversion loop of the 600 MWt design to reduce the temperature of the helium primary coolant prior to entering the inlets to the low pressure and high pressure compressors. This cooling process would reduce the work required to compress the helium in the compressors, thereby enhancing the net plant cycle efficiency.

Environmental Impacts. There are no substantial overall differences between the two-module 600 MWt Modular Helium Reactor and the three-module 350 MWt MHTGR. Compared to the MHTGR, the Modular Helium Reactor would have slightly more environmental impact in some resource areas, and slightly less environmental impact in other resource areas. A two-module 600 MWt Modular Helium Reactor would generate approximately 3 percent more spent nuclear fuel, increase worker doses, increase normal operational releases of some radioactive constituents, and increase the accident source term. Potential decreases in environmental impacts could result from less construction, decreased tritium releases during normal operations, reduced operating personnel, and less cooling water requirements.

A.3.1.2 *Small Advanced Heavy Water Reactor*

A reduced capacity HWR design does not now exist but could be developed to produce tritium at a level to meet the steady-state (3/16 goal) tritium requirement, but would have the capability, if necessary, to be modified to meet baseline (3/8 goal) tritium production requirements. The HWR evaluated in all other sections of this PEIS represents a downsized 8/8 goal quantity design from the original New Pro-

duction Reactor Program operated at the steady-state level.

The small advanced HWR would be designed for a nominal thermal output of approximately 470 MWt with a deep burn fuel cycle using uranium fuel. This would enable the small advanced HWR to produce steady-state (3/16 goal) tritium requirements. It would have the ability, with pre-planned plant upgrades and operational changes, to operate at a higher power level and produce the baseline 3/8 tritium goal quantity (DOE 1995a:1).

Specific design and operational features would be incorporated into the basic design to facilitate the modifications necessary to increase the tritium production to the 3/8 goal in a timely manner. These include the addition of fuel/targets into vacancy positions; operating at a higher capacity factor; reducing the fuel cycle duration; operating the reactor at a higher power density; and oversizing and making provisions for additional heat rejection system components (e.g., adding cooling tower cells).

Key Design Improvements. The layout and design of the small advanced HWR would be similar to the 3/8 concept with the primary difference being a more compact, and modularly designed facility. The small advanced HWR facility would occupy about 40 to 50 acres (within the limited access fence) as compared to 60 acres for the 3/8 design. The total area planned to be disturbed for the purpose of constructing and operating the small advanced HWR would be approximately 150 to 170 acres.

Because of the smaller plant configuration, the construction schedule will be shortened from the current design. Construction of the small advanced HWR complex would require approximately 5 years and 1,800 workers during the peak construction period.

Additional design improvements for the small advanced HWR would be a reduced number of systems consistent with passive reactor safety requirements; smaller heavy water inventory and lower primary coolant flow rates translating into smaller equipment and piping sizes; reduced shielding requirements based on reduced source terms and use of robotics; and smaller building sizes and concomitant reductions in bulk material quantities.

The small advanced HWR fuel/targets, core configuration, and primary reactor coolant system would be similar to, but notably smaller than, the HWR described in sections 3.4.2.1 and A.2.1.1. Outlying buildings, cooling towers, switchyard, and overall plant footprints dimensions would also be reduced for the small advanced HWR.

Some differences of key parameters between the small advanced HWR and the HWR design evaluated in this PEIS would be 470 MWt versus 990 MWt, 144 fuel/target assemblies versus 258, and a containment building which is less than 120 feet in diameter versus 140 feet. The design would still maintain the two reactor coolant loops with some reduction in the piping, heat exchanger, pressurizer and accumulator sizes. Also, the fuel cycle duration would be retained at 350 days with an annual capacity factor of 85 percent.

It should be emphasized that the description of the small advanced HWR represents a pre-preconceptual design based on knowledge of existing HWR designs, recent requirements for advanced light water reactors, and the varied production requirements defined in section 3.1.1.

A.3.2 Plutonium Disposition

This PEIS analyzes technology options that have been determined to be reasonable for the mission of producing tritium required for continuing stockpile support only. The ALWR and the MHTGR technologies offer the added benefit of being capable of producing steam for electricity production that could prove to be desirable in offsetting operational and capital costs. The HWR cannot produce steam efficiently and the APT cannot produce steam at all. The ALWR and a Gas-Cooled Modular Helium Reactor are under consideration to fulfill roles in the ultimate disposition of fissile materials declared surplus to national defense needs, particularly plutonium.

The current and planned dismantling of large quantities of the nuclear weapons in the Nation's stockpile has and will result in the generation of excess quantities of plutonium. Various alternatives have been considered that would place excess plutonium into relatively inaccessible forms conforming with the "spent fuel standard", in which the remaining plutonium is made as inaccessible for retrieval and

weapons use as the residual plutonium in spent nuclear fuel from commercial power reactors. Among these is the use of plutonium-based reactor fuels and the immobilization of diluted plutonium through vitrification in ceramic or metal immobilization techniques. Other options use accelerator or reactor-generated neutrons to virtually destroy plutonium through deep burn fissioning. The reactor technologies considered for tritium production could be used to fulfill a part of or all of the requirements for plutonium disposition. However, other alternatives are also under consideration for plutonium disposition, such as direct disposal to deep boreholes and use of reactors in other countries, that do not use tritium production technologies. Clearly, plutonium disposition alternatives should not be limited to those technologies that support tritium production uniquely. However, if a reactor is to be selected as the tritium supply technology, it will be evaluated by the plutonium disposition program to determine if partial requirements can be met. The Office of Fissile Materials Disposition published an Implementation Plan in November 1994, which describes the alternatives that will continue to be evaluated for plutonium disposition.

The National Academy of Science's report *Management and Disposition of Excess Weapons Plutonium* (NAS 1994a) did not consider a linkage between tritium production and plutonium disposition technologies to necessarily be desirable. The wider range of options available for plutonium disposition and the smaller capacity required for tritium production are cited as countervailing to linkage. The production of tritium in the same facilities that might also be used to dispose of weapons materials, which would fall under International Atomic Energy Agency safeguards, is also cited as a potential concern. The National Academy of Science committee also concluded that the cost savings from a dual purpose, tritium production/plutonium disposition technology strategy would not be great and might not be justified when balanced against the complications discussed above.

Excess plutonium materials are considered appropriate for use in reactor fuel and disposal as reactor spent fuel for three basic reasons:

- It would meet the "spent fuel standard";

- There is a path forward for material that meets the "spent fuel standard", i.e., ultimate disposition in a repository; and
- It may result in equivalent reciprocal actions from the Russians.

Each of the tritium supply technology alternatives is discussed below for plutonium disposition.

A.3.2.1 Advanced Light Water Reactor Technology

This PEIS evaluates the ALWR technology alternative for both large and small reactor versions for tritium production. The reactor models under evaluation for plutonium disposition include light water reactors. The four primary design concepts are:

- ABB-Combustion Engineering Pressurized Light Water Reactor, System 80+.
- General Electric Advanced Boiling Water Reactor (GE ABWR).
- Westinghouse Pressurized Light Water Reactor, PDR-1400.
- Westinghouse Pressurized Light Water Reactor, AP-600.

Without major modifications, typical light water reactors could burn a fuel consisting of mixed-oxides of plutonium-oxide and uranium-oxide in their reactor cores. Some light water reactors are designed to use mixed-oxides in 100 percent of their reactor cores. A number of operating or partially completed reactors could be modified to use full mixed-oxide cores, or a new full mixed-oxide reactor could be built with costs partly offset by later sales of electricity. Although the United States has no operating mixed-oxide fuel fabrication plant or mixed-oxide fuel-burning reactors today, this technology is technically demonstrated by the burning of mixed-oxide fuels in several light water reactors in other countries, and has been demonstrated by use in several U.S. reactors in the 1970s.

Burning mixed-oxide fuel in an ALWR would result in creating inaccessible forms of plutonium conforming with the "spent fuel standard." The ALWR

designs could be adapted for dual tritium production and plutonium burning on essentially a noninterference basis. Some thermal power degradation could occur as a result of producing tritium, but not a significant amount. Also, the cyclic tritium production campaigns and the effect that this might have on the fuel burn cycle might not maximize the annihilation of plutonium fuel constituents. Only one reactor of the models shown would be required for tritium production. If only one Large ALWR is used as the principal technology to dispose of excess plutonium, approximately 50 metric tons of plutonium could be disposed of over the 40-year reactor life. For the AP-600, approximately one-half this amount could be disposed of over the 40-year reactor life.

ABB-Combustion Engineering System 80+. The Combustion Engineering System 80+ is a standard pressurized water reactor design which incorporates evolutionary improvements to the System 80 design in operation at the Palo Verde Nuclear Generating Station. The Combustion Engineering System 80+ improvements include a ring-forged reactor vessel, greater design margins for major components, and improvements to safety systems. NRC issued final design approval on ABB-Combustion Engineering's 1,300 MWe System 80+ pressurized water reactor in July 1994.

The Combustion Engineering System 80+ design would preserve the System 80 design feature of accommodating mixed-oxide fuel loadings up to and including a full mixed-oxide reactor core loading. The higher decay heat loads after shutdown generated by a full mixed-oxide reactor core would be accommodated in the design of the various heat removal systems, the shutdown cooling system, spent nuclear fuel pool cooling system, and the component cooling water system.

The Combustion Engineering System 80+ design would maintain flexibility in its power output depending on the mode of power operation. As a uranium-oxide fueled power production plant, the core thermal rating would be 3,914 MWt. When loaded with mixed-oxides, the output would be 3,817 MWt. And, when operating as a tritium producer while loaded with uranium-oxide, the output would be 3,410 MWt.

Westinghouse Pressurized Water Reactors. The Westinghouse Electric Corporation's pressurized water reactor AP600 is a 600 MWe nuclear power plant that has a simpler overall design than other Westinghouse plants. The AP600 design includes enhanced safety margins in such areas as fuel rod thermal limits and corrosion protection features. The AP600 would use a natural circulation heat exchange loop connected to the reactor and located inside the containment for reactor residual heat removal. Application for approval is under review by the NRC for Westinghouse Electric Corporation's AP600 design.

This advanced pressurized water reactor system is projected to have the capability of producing tritium with either plutonium-oxide or uranium-oxide as fuel. To operate in this mode, the core assembly structure would need to be altered such that some light water reactor tritium-producing rods would replace some fuel rods. The impact this would have on thermal-hydraulic compatibility and passive safety remains to be evaluated. The PDR-1400 is an evolutionary reactor similar to the four loop Westinghouse designs of existing pressurized water reactors.

General Electric Boiling Water Reactor. General Electric has applied recent technology innovations to the development of an advanced design of its currently operating boiling water reactors. The 1,300 MWe Advanced Boiling Water Reactor focuses on overall plant simplification and the use of safety systems that do not require operator actions. The major innovations that have been made in the systems would rely on gravity or stored energy to ensure core cooling and decay heat removal. The NRC issued final design approval for General Electric's 1,300 MWe Advanced Boiling Water Reactor in July 1994.

The Advanced Boiling Water Reactor was originally designed to utilize full core loads of mixed-oxide fuel. The physical design of the core and the boiling water reactor core dynamics are such that no modifications to the reactor system are required for the use of mixed-oxide fuel over a wide range of plutonium loadings. If necessary, the Advanced Boiling Water Reactor has the flexibility to easily switch back to conventional uranium fuel, again without plant physical changes.

A.3.2.2 Modular High Temperature Gas-Cooled Reactor Technology

The MHTGR design evaluated in this PEIS for a tritium mission is based upon a 350 MWt steam cycle plant. In order to increase thermal efficiency, a direct cycle Gas Turbine Modular Helium Reactor pre-pre-conceptual design that could produce tritium as well as be used for plutonium disposition has been suggested. The module power rating for this reactor would be increased to 600 MWt. Where three 350 MWt MHTGR modules would be required to meet baseline tritium production requirements, only two 600 MWt Modular Helium Reactor modules would be required. The new Gas Turbine Modular Helium Reactor design is under evaluation for plutonium disposition purposes and is represented by the General Atomics 600 MWt design described in Section A.3.1.1. This reactor is designed to actually destroy plutonium through deep burn fissioning which results in a net plutonium destruction rate of approximately 65 percent. The technical, research and development, and demonstration requirements necessary to be completed for the Modular Helium Reactor substantially increase the technical, schedule, and cost risks of bringing this concept to maturity.

The Modular Helium Reactor could not be adapted for both tritium production and plutonium burning in a noninterference manner. The tritium production efficiency decreases by a factor of 4 when using plutonium fuel in a Modular Helium Reactor. Thus, utilizing the Modular Helium Reactor for tritium production of 3/8 goal quantities with plutonium fuel would require eight reactor modules as opposed to two with uranium fuel. This factor of 4 increase in the number of required 600 MWt Modular Helium Reactors is directly attributable to the fact that tritium targets can only be placed in the reflector material of the plutonium-fueled core and not within the fueled region of the core as they can with a uranium-fueled reactor. This limitation of the plutonium-consumption Modular Helium Reactor serves to reduce by a factor of 4 the number of targets in each reactor available to produce the required amount of tritium, and thus increases the number of required plutonium-fueled reactor modules by the same factor.

Correspondingly, assuming that it is possible to extrapolate this data from the 600 MWt direct cycle

gas turbine reactor technology to the 350 MWt MHTGR technology proposed for tritium production, the three 350 MWt reactors proposed to produce the 3/8 goal quantity of tritium utilizing uranium fuel would need to be increased by a factor of 4 if plutonium fuel is utilized. This would result in a requirement of 12 350 MWt MHTGR modules to produce the 3/8 goal quantity of tritium. However, only six 350 MWt MHTGRs would be required to produce the steady-state (3/16 goal) requirement. In the event that surge tritium production is required, some of the six 350 MWt reactors could be refueled with uranium fuel in order to allow for increased placement of target rods in the core, and thus meet the surge requirement.

It is not expected that the six 350 MWt reactors could dispose of the same amount of plutonium as one large ALWR over the 40-year reactor life. The inefficiencies induced by using a dual purpose strategy are not entirely known; however, it could be expected that tritium production cycle interrupts would cause some minor delays in the plutonium disposition timetable.

A.3.2.3 Heavy Water Reactor Technology

An advanced HWR design for tritium production could possibly use plutonium fuel. The plutonium burn-up for such a reactor is estimated to be 35 percent. If a single HWR at the power level required to produce the annual goal quantity of tritium is used for plutonium disposition then approximately 70 years would be required to dispose of 50 tons of plutonium. Since this time-frame is greater than the expected life of such a reactor, two reactors would be required. If selected for tritium supply, the HWR would then be evaluated for a plutonium disposition mission.

A.3.2.4 Accelerator Production of Tritium Technology

Accelerator-based conversion technologies have been investigated as possible plutonium disposition alternatives. Accelerator-based conversion would use a sub-critical reactor augmented by an accelerator to "deep burn" plutonium, which could eliminate in excess of 90 percent of the processed plutonium over the campaign. This technique would allow plutonium disposition to progress well beyond the "spent fuel standard." The technique involves the use of particle accelerator module, at the appropriate power level, that is used as the precursor for the APT alternative evaluated in this PEIS.

The target systems are, however, quite different. For plutonium disposition, either molten salt or particle bed systems could be used. In both cases, materials containing surplus plutonium particles would be irradiated with neutrons until a large portion of the plutonium was eliminated through fissioning. Excess commercial power could not be generated with this scheme in order to exploit the energy value of the plutonium; however, enough power could be generated to operate the particle accelerator once started. In theory, an accelerator-based system could provide plutonium disposition services as well as produce tritium; however, one process would compete with the other for neutrons. For plutonium "deep burn" disposition, it is estimated that up to three accelerator-based facilities, each having four target blankets arrays, would be required for a 20 year disposition campaign. Only one such facility with two lithium-6 target-blanket systems (or continuous helium-3 target systems) would be required to produce anticipated annual quantities of tritium.

This option is only at the early paper study stage and would not be available on a large scale for decades. If the estimated performance could be attained, however, such systems could destroy plutonium at a rate (per unit of thermal energy) comparable to those of the other destruction-oriented options (e.g., reactors) and could reach high reduction factors for plutonium inventory more rapidly than many of the other options.

APPENDIX B

Appendix B

APPENDIX B: AIR QUALITY AND ACOUSTICS

B.1 AIR QUALITY

B.1.1 Introduction

This appendix provides detailed data that support impact assessments to air quality and acoustics addressed in the *Programmatic Environmental Impact Statement (PEIS) for Tritium Supply and Recycling* sections 4.X.2 affected environment and 4.X.3 environmental impacts. The data presented includes background or ambient concentrations of criteria pollutants, emission inventories from site-related activities, and tritium supply and recycling-related emissions. The tables included in sections B.1.3.2 through B.1.3.6 contain site-specific baseline information applicable to air quality assessments. Section B.1.4 contains air quality emissions data relative to the tritium supply technologies and recycling alternatives considered in the program. Figures B.1.3.2-1, B.1.3.3-1, B.1.3.4-1, B.1.3.5-1, and B.1.3.6-1 contain wind rose data pertinent to the analysis of air emissions effects from baseline and No Action and also from tritium supply and recycling. Locations of air monitoring stations from which air quality data were collected are provided in figures B.1.3.2-2, B.1.3.4-2, and B.1.3.6-2.

B.1.2 Methodology and Models

The assessment of potential impacts to air quality is based upon comparison of proposed project effects with applicable standards and guidelines. The assessment of these emissions used the Industrial Source Complex Short-Term model recommended by the Environmental Protection Agency (EPA) for point, area, and volume sources which estimates dispersion of emissions from these sources.

The performance of the Industrial Source Complex Short-Term model has been evaluated with field data for its point source submodel (EPA 1977a; EPRI 1983a; EPRI 1985a; EPRI 1988a) and for its special features, such as gravitational settling/dry deposition option (EPA 1981a; EPA 1982a) and building downwash option (APCA 1986a;

EPA 1981a). The Industrial Source Complex Short-Term model is an extended vision of the single source (CRSTER) model. From the validation studies for the point source model (the CRSTER model) based on field data measured at four large power plants, it was concluded that the model acceptably predicts the upper percentile of the frequency distribution of 1-hour concentrations and of the corresponding distributions of 24-hour concentrations. Concentrations over the remainder of the frequency distributions are significantly underpredicted. The second-highest 1-hour concentrations were predicted within a factor of 2 at two-thirds of the field sampling sites for elevated power plant plumes. The second-highest 24-hour concentrations tended to be underpredicted by the model, with the ratio of predicted concentration to measured concentration ranging from 0.2 to 2.7 at about 90 percent of the sampling sites (EPA 1977a:F-31).

In other validation studies for the point source model, the CRSTER model predicted peak short-term (1-, 3-, and 24-hour) concentration values within 30 to 70 percent at a plain site (EPRI 1983a:7-1). The CRSTER model predicted peak 1-hour concentrations within 2 percent and underpredicted peak 3-hour concentrations by approximately 30 percent at a moderately complex terrain site (EPRI 1985a:7-1). The Industrial Source Complex Short-Term model overpredicted 1-hour concentrations by approximately 60 percent with better predictions for longer time periods at an urban site (EPRI 1988a:5-2). Uses of gravitational settling/dry deposition and building downwash options were found to improve the model performance significantly over that of the model without such features (APCA 1986a; EPA 1981a; EPA 1982a).

The air quality modeling analysis performed for the candidate sites is a "screening level" analysis incorporating conservative assumptions applied to each of the sites such that the impacts associated with the respective alternatives could be compared among the sites. These conservative assumptions will overestimate the pollutant concentrations at each of the sites.

The assumptions incorporated into the air quality modeling at each site are as follows: major source criteria pollutant emissions were modeled using actual source locations and stack parameters to determine environmental baseline and No Action criteria pollutant concentrations; toxic/hazardous pollutant emissions were modeled from a single source centrally located within the complex of facilities on each site assuming a 10-meter stack height, a stack diameter of 1-foot, stack exit temperature equal to ambient temperature, and a stack exit velocity equal to 0.01 meters per second.

Emissions from the tritium supply and recycling facilities were located at the proposed tritium supply site (TSS) identified for each site assuming a single stack 10 meters in height, a stack diameter of 1-foot, stack exit temperature equal to ambient temperature, and stack exit velocity equal to 0.01 meters per second.

These assumptions would tend to overestimate pollutant concentrations since no credit is given to spatial and temporal variations of emission sources.

Potential impacts on air quality from construction were assessed on a qualitative basis. A more detailed and quantitative assessment will be done in the site-specific *National Environmental Policy Act* (NEPA) documents. This PEIS assessment of impacts from operation of the alternatives under consideration used a "screening" level analysis and was based on conservative assumptions for modeling of potential

impacts. The assessment in the site-specific tiered NEPA documents would be more refined, with detailed design source characteristics and exact source emission locations.

B.1.3 Supporting Data

B.1.3.1 Overview

This section provides supporting information related to the meteorology for each of the five candidate sites for tritium supply and recycling. Table B.1.3.1-1 presents the air quality standards applicable to each site, while table B.1.3.1-2 presents maximum allowable Prevention of Significant Deterioration concentration increments also applicable to each site. Table B.1.3.1-3 presents the pollutant emissions from a typical natural gas-fired power plant. These emissions represent the expected increase in pollutants if a dedicated power plant were constructed to support the Accelerator Production of Tritium (APT) technology. The percent increase in expected emissions is identified in each air quality impact section for each potential site in chapter 4. Additional tables are presented for each site for background monitoring stations, applicable air monitoring data, and relevant emissions inventory. Figures depicting annual mean wind speeds and wind direction frequencies for each site and locations of ambient air quality monitoring stations are presented for those sites which conduct monitoring of ambient air quality.

TABLE B.1.3.1-1.—Ambient Air Quality Standards Applicable to the Candidate Sites

Pollutant	Averaging Time	Primary NAAQS ^a ($\mu\text{g}/\text{m}^3$)	Secondary NAAQS ($\mu\text{g}/\text{m}^3$)	Idaho ^b (INEL) ($\mu\text{g}/\text{m}^3$)	Nevada (NTS) ($\mu\text{g}/\text{m}^3$)	Tennessee (ORR) ($\mu\text{g}/\text{m}^3$)	Texas (Pantex) ($\mu\text{g}/\text{m}^3$)	Georgia and South Carolina (SRS) ($\mu\text{g}/\text{m}^3$)
Criteria Pollutant								
Carbon monoxide	8-hour	10,000	c	10,000	10,000	10,000	10,000	10,000
	1-hour	40,000	c	40,000	40,000	40,000	40,000	40,000
Lead	Calendar quarter	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrogen dioxide	Annual	100	100	100	100	100	100	100
Ozone	1-hour	235	235	235	235	235	235	235
Particulate matter	Annual	50	50	50	50	50	50	50
	24-hour	150	150	150	150	150	150	150
Sulfur dioxide	Annual	80	c	80	80	80	80	80
	24-hour	365	c	365	365	365	365	365
	3-hour	c	1,300	1,300	1,300	1,300	1,300	1,300
Other Mandated Pollutants								
Beryllium	24-hour	c	c	c	c	c	0.01	c
Hydrogen fluoride	30-day	c	c	c	c	1.2	0.8	0.8
	7-day	c	c	c	c	1.6	1.6	1.6
	24-hour	c	c	c	c	2.9	2.9	2.9
	12-hour	c	c	c	c	3.7	3.7	3.7
	8-hour	c	c	c	c	250	c	c
Hydrogen sulfide	1-hour	c	c	c	112	c	c	c
Total suspended particulates	Annual	c	c	60	c	c	c	75
	24-hour	c	c	150	c	150	c	c

^a The National Ambient Air Quality Standards, other than those for ozone, particulate matter, and those based on annual averages, are not to be exceeded more than once per year. The ozone standard is attained when the expected number of days per year with maximum hourly average concentrations above the standard is less than or equal to 1. The 24-hour particulate matter standard is attained when the expected number of days with a 24-hour average concentration above the standard is less than or equal to 1. The annual arithmetic mean particulate matter standard is attained when the expected annual arithmetic mean concentration is less than or equal to the standard.

^b The Idaho annual standards are never to be exceeded; short-term standards are not to be exceeded more than once per year, unless otherwise noted.

^c There is no standard.

Note: NAAQS - National Ambient Air Quality Standard.

Source: 40 CFR 50; IN DHW 1990b; NT NAC 1991a; OR DHE 1991a; PX ACB 1993a; SR DHEC 1992b.

TABLE B.1.3.1-2.—Maximum Allowable Prevention of Significant Deterioration Concentration Increments for the Candidate Sites

Pollutant	Averaging Time	Prevention of Significant Deterioration Increment ^a (μg/m ³)		
		Class I	Class II	Class III
Nitrogen dioxide	Annual	2.5	25	50
Particulate matter	Annual	4	17	34
	24-hour	8	30	60
Sulfur dioxide	Annual	2	20	40
	24-hour	5	91	182
	3-hour	25	512	700

^a Short-term increments are not to be exceeded more than once per year.

Source: 40 CFR 52.21.

TABLE B.1.3.1-3.—Pollutant Emissions from Natural Gas-Fired Turbines

Pollutants	Emission Factor (lb/MMBtu)	Emission Rate ^a (tons/yr)
Ammonia ^b	0.0065	58.301
Carbon dioxide	112	1,004,568.768
Carbon monoxide	0.0084	75.343
Formaldehyde ^b	0.0027	24.217
Sulfur oxides (as SO ₂)	0.0006	5.382
Nonmethane hydrocarbons ^b	0.0032	28.702
Nitrogen oxides	0.035	313.928
Particulate matter	0.02	179.387
Total organic compounds (as methane) ^b	0.014	125.571
Volatile organic compounds	0.024	215.265

^a Based on a 600 MWe natural gas-fired turbine.

^b Pollutants result from operation of selective catalytic reduction with water injection used to control nitrogen oxide and carbon monoxide.

Source: EPA 1995a; SPS 1995a.

B.1.3.2 Idaho National Engineering Laboratory

This section provides information on meteorology and climatology, atmospheric dispersion characteristics, annual mean wind speeds and direction frequencies (figure B.1.3.2-1), and locations of ambient air quality monitoring stations (figure B.1.3.2-2) at the Idaho National Engineering Laboratory (INEL). Air quality monitoring data and emission source inventories for criteria pollutants are presented in tables B.1.3.2-1 and B.1.3.2-2, respectively. Table B.1.3.2-3 presents Prevention of Significant Deterioration Sources and nearby Class I areas. Emission rates and maximum site boundary concentrations of toxic/hazardous air pollutants and estimated ambient concentrations of criteria pollutants from baseline sources are presented in tables B.1.3.2-4 and

B.1.3.2-5, respectively. This information supports data presented in section 4.2.2.3.

Meteorology and Climatology. Prevailing wind directions are from the southwest to west-southwest with a secondary maximum frequency from the north-northeast to northeast. Figure B.1.3.2-1 shows annual mean wind speeds and direction frequencies for 1986 at the 33-foot level of the INEL meteorological tower. The average annual wind speed measured at the 20-foot level at the Central Facilities Area Weather Station is 7.5 miles per hour (mph). Monthly average wind speeds range from 5.1 mph in December to 9.3 mph in April and May.

The average annual temperature is 42 °F; the average monthly range is from 16 °F in January to

68 °F in July (NOAA 1991d:3). The average annual relative humidity is 50 percent, with average monthly values ranging from 30 percent in July to 70 percent in February.

The average annual precipitation is 9.1 inches. The average monthly precipitation ranges from 0.4 inches in July to 1.28 inches in May. A large portion of the precipitation occurs as snow during winter. The average annual snowfall is 42.6 inches.

The maximum instantaneous wind gust recorded at the Central Facilities Area Weather Station (20-foot level) was 78 mph from the west-southwest, and the maximum hourly average wind speed, also from the west-southwest, was 51 mph (IN DOE 1989b:28,30).

The months of June, July, and August each average two to three thunderstorm days. Hail storms occur occasionally, with the hail usually smaller than 0.25 inches in diameter. Tornadoes are very infrequent in the area. Between 1950 and 1989, a total of five funnel clouds and no tornadoes were sighted within the boundary of INEL. The estimated probability of a tornado striking a point at INEL is 6 in 10 million per year (NRC 1986a:32).

Atmospheric Dispersion Characteristics. Data collected at the Central Facilities Area Weather Station for calendar year 1986 indicate that unstable conditions occur approximately 38 percent of the time, neutral conditions approximately 4 percent of the time, and stable conditions approximately 58 percent of the time, on an annual basis.

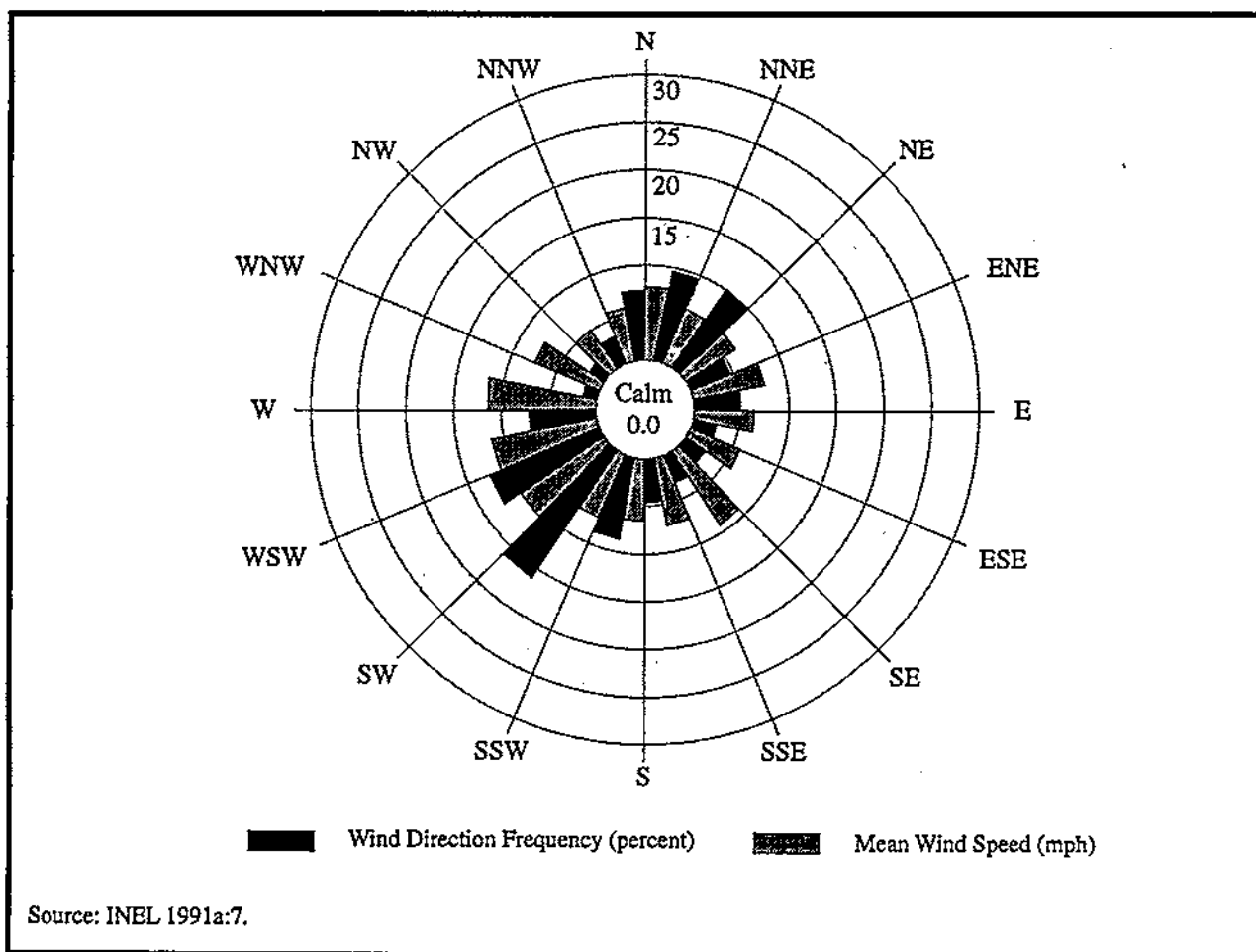
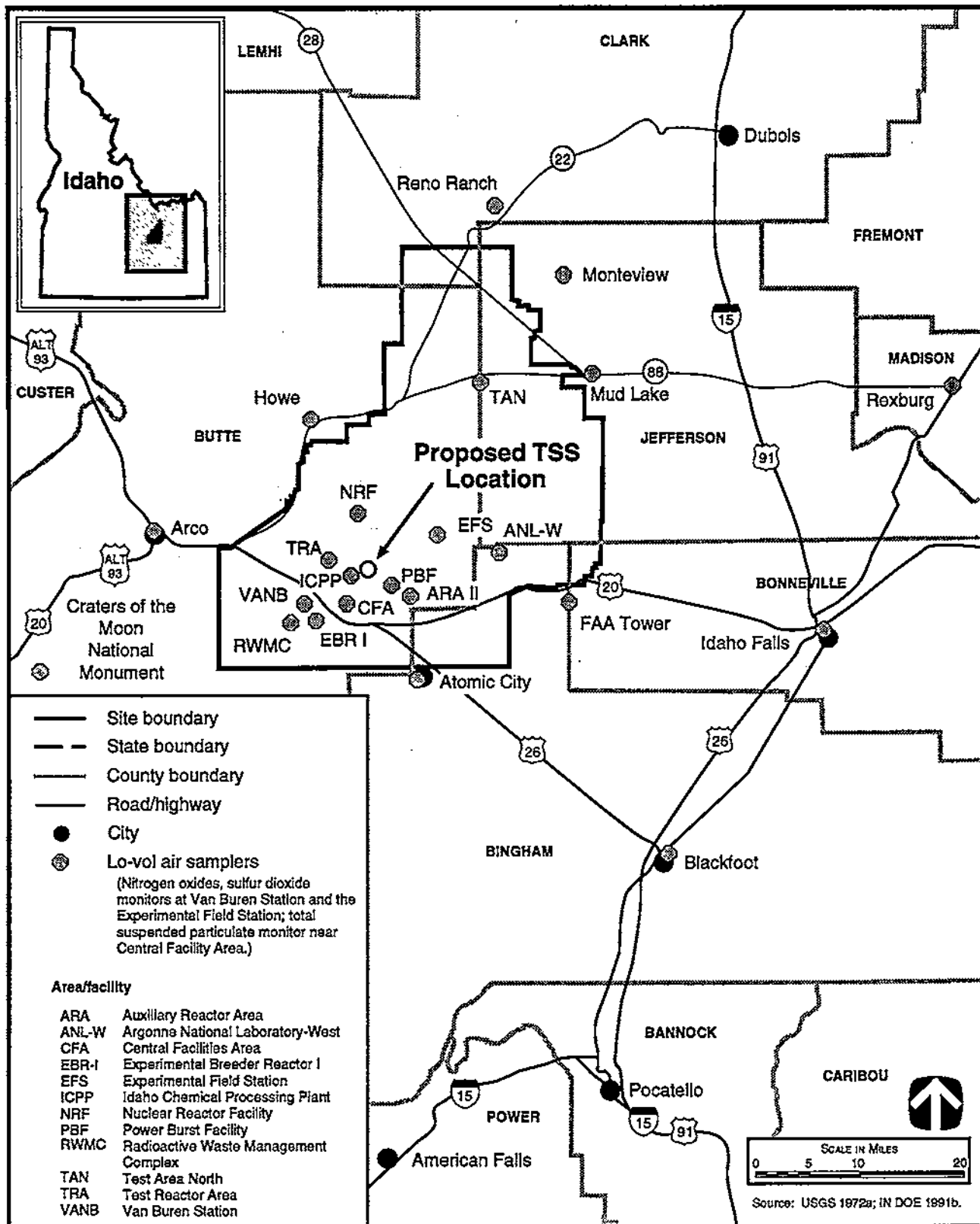


FIGURE B.1.3.2-1.—Wind Distribution at Idaho National Engineering Laboratory, 1986 (33-foot level).



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**FIGURE B.1.3.2-2.—Ambient Air Quality Monitoring Network
at Idaho National Engineering Laboratory.**

TABLE B.1.3.2-1.—Ambient Air Quality at Idaho National Engineering Laboratory

Monitoring Station	Time Period	Ambient Concentration ($\mu\text{g}/\text{m}^3$)							
		Sulfur Dioxide			Nitrogen Oxide	Particulate Matter		Total Suspended Particulates ^a	
		Annual	Max. 24-hour	Max. 3-hour	Annual	Annual	Max. 24-hour	Annual	Max. 24-hour
Central Facility Area	July 1989- June 1990	b	b	b	b	14	32	40	88
Experimental Field Station	Jan. 1990- Dec. 1990	b	b	b	5	b	b	b	b
Van Buren Station	Oct. 1989- Mar. 1991	0.2	8	14	b	b	b	b	b

^a Total suspended particulates data taken from DOE 1992h.^b Not measured.

Note: Carbon monoxide, lead, and ozone not measured at this site.

Source: DOE 1992h; DOE 1992i; IN DOE 1990a; IN DOE 1991c.

TABLE B.1.3.2-2.—Source Emission Inventory for Idaho National Engineering Laboratory, 1989

Source	Criteria Pollutant – Emission Rate (lb/hr)				
	Carbon Monoxide	Lead	Nitrogen Oxide	Particulate Matter	Sulfur Dioxide
Argonne National Laboratory—West 18	9.6	0.000514	1.26	3.74	13.9
Argonne National Laboratory—West 19	0.55	0.000010	0.017	0.18	0.25
Central Facilities Area 20	6.21	0.000449	1.05	25.6	12.2
Central Facilities Area 21	0.64	0.000046	0.16	0.26	1.25
Idaho Chemical Processing Plant 22	119	0.000612	228	13.5	18.5
Idaho Chemical Processing Plant 23	12.3	0.025100	19.4	5.57	6.45
Power Burst Facility 24	2.28	0.000026	0.027	9.2	0.71
Power Burst Facility 25	10.2	0.000009	0.055	0.03	0.26
Power Burst Facility 26	0.035	0.000008	0.011	0.001	0.23
Power Burst Facility 27	10.9	0.000019	0.25	0.34	0.9
Power Burst Facility 28	0.025	0.000006	0.018	0.01	0.17
Radioactive Waste Management Complex 29	1.35	0.000016	0.073	0.44	0.41
Test Reactor Area 30	21.1	0.000226	22.8	8.76	6.08
Test Area North 31	7.68	0.000414	2.28	3.43	12.7
Test Area North 32	5.78	0.000329	3.88	2.24	8.97
Test Area North 33	0.85	0.000026	0.17	0.84	0.7

Source: IN DOE 1991e.

TABLE B.1.3.2-3.—Prevention of Significant Deterioration Sources and Concentration Increments Consumed at Idaho National Engineering Laboratory Boundary and Nearby Class I Area

Prevention of Significant Deterioration Source		Prevention of Significant Deterioration Concentration	
Description	Location	INEL Boundary	Craters of the Moon
Coal-Fired Steam Generating Plant	Next to the Idaho Chemical Processing Plant	<10 percent of Class II allowable sulfur dioxide and total suspended particulates Prevention of Significant Deterioration increments	<20 percent of Class I allowable sulfur dioxide and total suspended particulates Prevention of Significant Deterioration increments
Fuel Processing Restoration Facility	Idaho Chemical Processing Plant	<1 percent of Class II allowable nitrogen dioxide and Prevention of Significant Deterioration increment	<1 percent of Class I allowable nitrogen dioxide and Prevention of Significant Deterioration increment

Source: DOE 1992h.

TABLE B.1.3.2-4.—Emission Rates and Maximum Site Boundary Concentration of Toxic/Hazardous Air Pollutants at Idaho National Engineering Laboratory, 1989

Pollutant	Emission Rate (tons/yr)	Maximum Annual Average Concentration ($\mu\text{g}/\text{m}^3$)	Acceptable Ambient Concentration ^a ($\mu\text{g}/\text{m}^3$)
Acetaldehyde	0.2	0.011	0.45
Ammonia	7.16	6	180
Arsenic	0.03	9.0×10^{-5}	2.3×10^{-4}
Benzene	0.58	0.029	0.12
Butadiene	0.43	1.0×10^{-3}	3.6×10^{-3}
Carbon tetrachloride	0.03	6.0×10^{-3}	0.067
Chloroform	0.002	4.0×10^{-4}	0.043
Cyclopentane	0.39	2.7	17,000
Formaldehyde	3.64	0.012	0.077
Hexavalent chromium	0.03	6.0×10^{-5}	8.3×10^{-5}
Hydrazine	0.01	1.0×10^{-6}	3.4×10^{-4}
Hydrochloric acid	1.65	0.98	7.5
Mercury	0.22	0.042	1
Methylene chloride	1.21	0.006	0.24
Naphthalene	0.02	18	500
Nickel	1.1	2.7×10^{-3}	4.2×10^{-3}
Nitric acid	106.92	0.64	50
Perchloroethylene	1.08	0.11	2.1
Phosphorus	0.23	0.3	1
Potassium hydroxide	2.31	0.2	20
Propionaldehyde	0.12	0.3	4.3
Styrene	0.01	1.3	1,000
Toluene	0.64	370	3,750
Trichloroethylene	0.005	9.7×10^{-4}	0.077
Trimethylbenzene	0.1	100	1,230
Trivalent chromium	0.04	0.036	5

^a Acceptable ambient concentrations are increments that apply only to new (not existing) sources and are used here only as reference levels.

Source: DOE 1995v; IN DHW 1995a; IN DHW 1995b.

TABLE B.1.3.2-5.—Estimated Ambient Concentration of Criteria Pollutants from Baseline Sources at Idaho National Engineering Laboratory, 1991

Pollutant	Averaging Time	Most Stringent Regulation or Guideline ($\mu\text{g}/\text{m}^3$)	Maximum Background Concentrations ($\mu\text{g}/\text{m}^3$)	INEL Contribution Concentration ^a ($\mu\text{g}/\text{m}^3$)	Baseline Concentration ($\mu\text{g}/\text{m}^3$)
Carbon monoxide	8-hour	10,000	b	284	284
	1-hour	40,000	b	614	614
Lead	Calendar Quarter	1.5	b	0.001	0.001
Nitrogen dioxide	Annual	100	5	4	9
Ozone	1-hour	235	b	b	b
Particulate matter	Annual	50	14	5	19
	24-hour	150	32	80	112
Sulfur dioxide	Annual	80	0.2	6	6.2
	24-hour	365	8	135	143
	3-hour	1,300	14	579	593
Total suspended particulates	Annual	60	40	5	45
	24-hour	150	88	80	168

^a The concentrations are maximum values; all maximum concentrations occur on U.S. 20/26.

^b Not modeled due to negligible emission rate.

Source: 40 CFR 50; DOE 1995v; IN DHW 1992b.

B.1.3.3 Nevada Test Site

This section provides information on meteorology and climatology, atmospheric dispersion characteristics, and annual mean wind speeds and direction frequencies (figure B.1.3.3-1) at the Nevada Test Site (NTS). Air quality monitoring data, emission source inventories for criteria pollutants, and estimated ambient concentrations of criteria pollutants from existing sources at NTS are presented in tables B.1.3.3-1, B.1.3.3-2, and B.1.3.3-3, respectively. This information supports data presented in section 4.3.2.3.

Meteorology and Climatology. Figure B.1.3.3-1 shows annual mean wind speeds and direction frequencies for 1990 measured at the 33-foot level of Desert Rock National Weather Service station near NTS. Overall, predominating winds are southerly during summer and northerly during winter. The general downward slope in the terrain from north to south results in an intermediate scenario that is reflected in the characteristic diurnal wind reversal from southerly winds during the day to northerly winds at night. This north to south reversal is strongest in the summer and, on occasion, becomes intense enough to override the wind regime associated with large-scale pressure systems.

Average annual wind speeds and direction vary with location. At higher elevations on Pahute Mesa, the average annual wind speed is 10.5 mph. The prevailing wind direction during winter months is north-northeasterly, and during summer months, winds are southerly. In Yucca Flat the average annual wind speed is 7 mph. The prevailing wind direction during winter months is north-northwesterly and during summer months is south-southwesterly. At Mercury, NV, the average annual wind speed is 8 mph, with northwesterly prevailing winds during the winter months and southwesterly winds during the summer months.

Elevation influences temperatures on NTS. At an elevation of 6,560 feet above mean sea level on Pahute Mesa, the average daily maximum/minimum temperatures are 40 °F/28 °F in January and 80 °F/62 °F in July. In Yucca Flat, 3,920 feet MSL, the average daily maximum/minimum temperatures are 51 °F/21 °F in January and 96 °F/57 °F in July. The extreme temperatures at Mercury are 69 °F/12 °F in January and 109 °F/59 °F in July.

The average annual temperature in the NTS area is 66.3 °F (NOAA 1991d:3). Average monthly temperatures range from 44.5 °F in January to 89.8 °F in July. Relative humidity readings taken 4 times per

day range from 11 percent in June to 55 percent in January and December.

Annual precipitation in southern Nevada is very light and depends largely upon elevation. On NTS, the mesas receive an average annual precipitation of 9 inches, which includes winter snow accumulations. The lower elevations receive approximately 6 inches of precipitation annually, with occasional snow accumulations lasting only a few days (NT DOC 1968a).

Precipitation usually falls in isolated showers with large variations in precipitation amounts within a shower area. Summer precipitation occurs mainly in July and August when intense heating of the ground below moist air masses triggers thunderstorm development. On rare occasions, a tropical storm will move northeastward from the coast of Mexico, bringing heavy precipitation during August and/or September.

Wind speeds in excess of 60 mph, with gusts up to 107 mph may be expected to occur on a 100-year return period (NT DOC 1968a). Other than temperature extremes, severe weather in the region includes occasional thunderstorms, lightning, tornadoes, and sandstorms. Severe thunderstorms may produce high precipitation with durations of approximately one hour, and may create a potential for flash flooding (NT DOE 1983a:26). Tornadoes have been observed in the region but are infrequent. The estimated probability of a tornado striking a point at NTS is 3.0×10^{-7} per year (NRC 1986a:32).

Atmospheric Dispersion Characteristics. Data collected for calendar year 1990 indicate that unstable conditions occur approximately 25 percent of the time, neutral conditions approximately 38 percent, and stable conditions approximately 37 percent, on an annual basis.

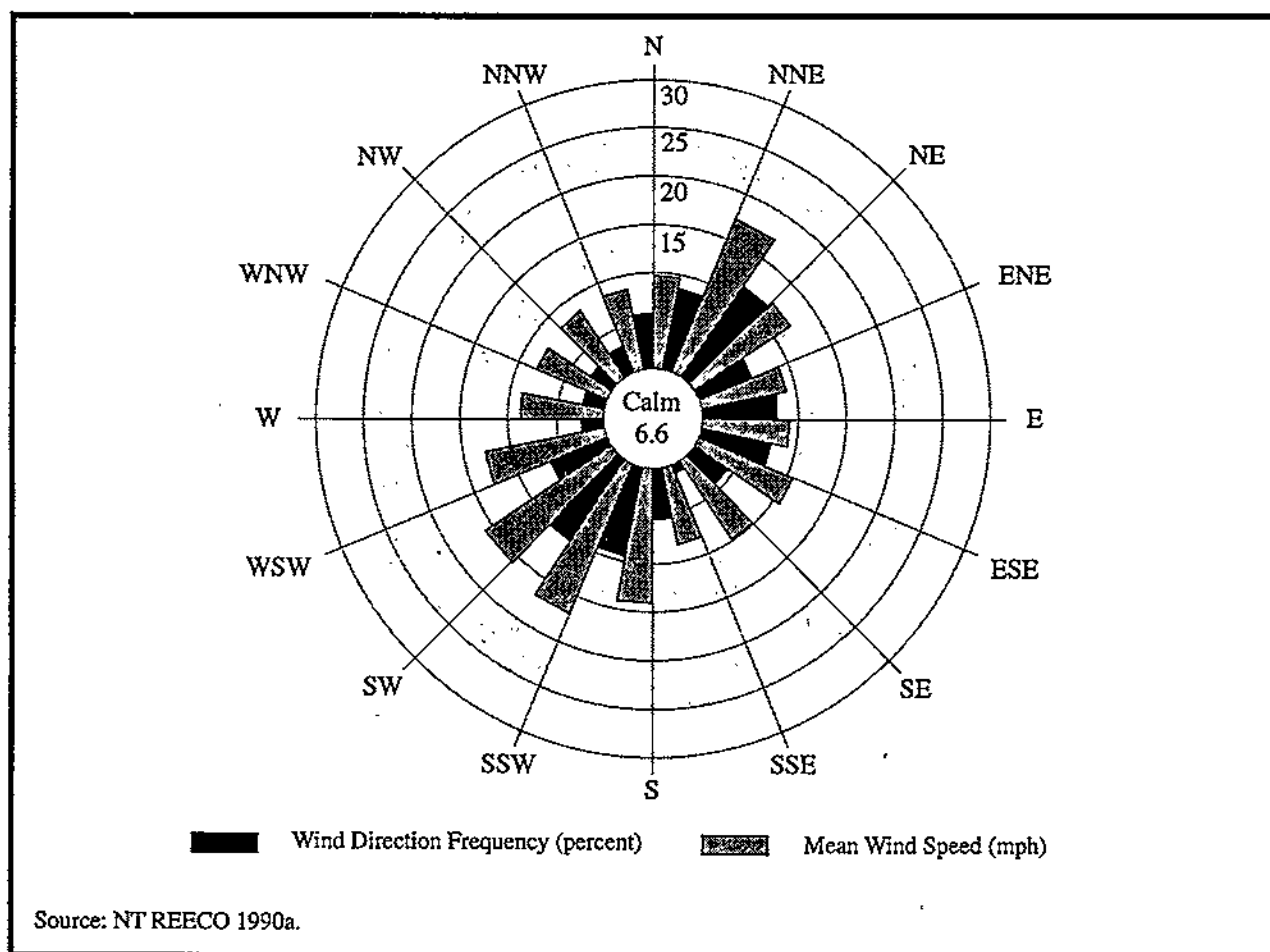


FIGURE B.1.3.3-1.—Wind Distribution at Nevada Test Site, 1990 (33-foot level).

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TABLE B.1.3.3-1.—Ambient Air Quality Data for Nevada Test Site, 1990

Monitoring Station	Time Period	Ambient Concentration ($\mu\text{g}/\text{m}^3$)					
		Sulfur Dioxide		Carbon Monoxide		Particulate Matter ^a	
		Annual	Max. 24-hour	Max. 3-hour	Max. 8-hour	Max. 1-hour	Annual Max. 24-hour
Area 6	Aug. 15, 1990- Sep. 15, 1990	^b	0	0	1,145	1,947	^b 20.2
Area 12	Aug. 15, 1990- Sep. 15, 1990	^b	15.7	52.4	2,290	2,748	^b 45.4
Area 23	Aug. 15, 1990- Sep. 15, 1990	^b	39.3	65.4	1,374	1,374	^b 78.3

^a Particulate matter less than 10 microns in diameter.^b Not measured.

Note: Nitrogen oxide, lead, and ozone were not measured at this site.

Source: NT REECO 1990a.

TABLE B.1.3.3-2.—Source Emission Inventory for Nevada Test Site, 1992

Source	Criteria Pollutant—Emission Rate (lb/hr)	
	Particulate Matter	Sulfur Dioxide
Area 1 Rotary Dryer	7.1	^a
Area 6 Boiler	2.9	2.5
Area 12 Boiler	2.8	2.8
Area 23 Boiler	3.1	3.6
Area 23 Boiler	2.8	2.8
Area 23 Incinerator	0.75	3.0

^a No source indicated.

Source: NT DCNR 1992a.

TABLE B.1.3.3-3.—Estimated Ambient Concentration of Criteria Pollutants from Existing Sources at Nevada Test Site, 1990

Pollutant	Averaging Time	Most Stringent Regulation or Guideline ($\mu\text{g}/\text{m}^3$)	Maximum Background Concentrations ($\mu\text{g}/\text{m}^3$)	NTS Contribution Concentration ($\mu\text{g}/\text{m}^3$)	Baseline Concentration ($\mu\text{g}/\text{m}^3$)
Carbon monoxide	8-hour	10,000	2,290	^a	2,290
	1-hour	40,000	2,748	^a	2,748
Lead	Quarter	1.5	^b	^a	^a
Nitrogen dioxide	Annual	100	^b	^a	^a
Ozone	1-hour	235	^b	^b	^b
Particulate matter	Annual	50	^b	8.39	8.39
	24-hour	150	78.3	94.3	172.6
Sulfur dioxide	Annual	80	^b	6.9	6.9
	24-hour	365	39.3	77.7	117
	3-hour	1,300	65.4	595.2	660.6

^a No sources indicated.^b Not monitored.

Note: Monitoring data based on 1 month of sampling from August 15 to September 15, 1990.

Source: 40 CFR 50; NT NAC 1991a; NT DCNR 1992a; NT REECO 1990a.

B.1.3.4 Oak Ridge Reservation

This section provides information on meteorology and climatology, atmospheric dispersion characteristics, annual mean wind speeds and direction frequencies (figure B.1.3.4-1), and locations of ambient air quality monitoring stations (figure B.1.3.4-2) at the Oak Ridge Reservation (ORR). Air quality monitoring data and emission source inventories for criteria pollutants at ORR are presented in tables B.1.3.4-1 and B.1.3.4-2, respectively. Emission rates and maximum site boundary or public access highways within the site boundary concentrations of toxic/hazardous air pollutants and estimated ambient concentrations of criteria pollutants from existing sources at ORR are presented in tables B.1.3.4-3 and B.1.3.4-4, respectively. This information supports data presented in section 4.4.2.3.

Meteorology and Climatology. The wind direction above the ridge tops and within the valley tends to follow the orientation of the valley. On an annual basis, the prevailing winds at the National Weather Service station in the city of Oak Ridge are either up-valley, from west to southwest, or down-valley, from east to northeast. Figure B.1.3.4-1 shows annual mean wind speeds and direction frequencies for 1990 measured at the 98-foot level of the ORR meteorology tower. The prevailing wind directions are from the southwest and northeast quadrants. Annual mean wind speeds measured in the region are relatively low averaging 4.5 mph at the National Weather Service station at the 46-foot level and 4.7 mph at the 33-foot level at the ORR Bethel Valley monitoring station.

The average annual temperature is 57.5 °F; temperatures vary from an average daily minimum of 27.7 °F in January to an average daily maximum of 87.2 °F in July. Relative humidity readings taken 4 times per day range from 51 percent in April to 92 percent in August and September (NOAA 1991c:3).

The average annual precipitation measured in Bethel Valley is 51.5 inches, while the average annual precipitation for the National Weather Service station in Oak Ridge is 54 inches. The maximum monthly precipitation recorded at the National Weather Service station was 19.3 inches in July 1967, while the

maximum rainfall in a 24-hour period observed at the Oak Ridge National Weather Service station was 7.5 inches recorded in August 1960. The average annual snowfall as measured at the Oak Ridge National Weather Service station is 10.1 inches.

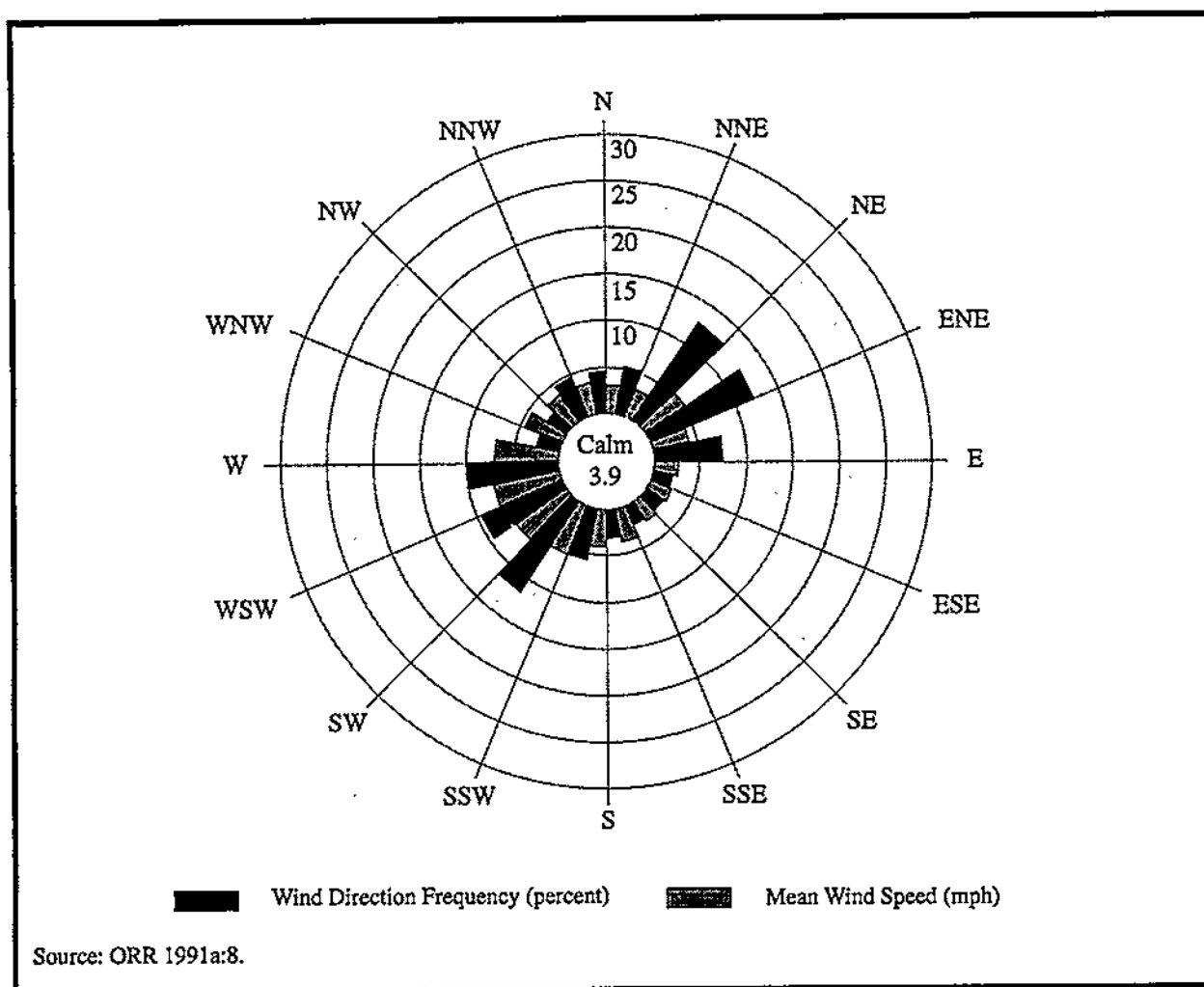
Damaging winds are uncommon in the region. Peak gusts recorded in the area range from 60 to 69 mph for the months of January through July; from 49 to 60 mph for August, September, and December; and 36 to 45 mph in October and November (ORNL 1982a). The fastest mile wind speed (the 1 mile passage of wind with the highest speed for the day) recorded at the Oak Ridge National Weather Service station for the period of record 1958 through 1979 was 59.1 mph in January 1959.

The extreme mile wind speed at 30 feet that is predicted to occur near ORR once in 100 years is approximately 89 mph. The approximate values for occurrence intervals of 10, 25, and 50 years are 64, 74, and 76 mph, respectively (ORNL 1981:3.3-7).

Between 1916 and 1972, there were 25 tornadoes reported in the counties of Tennessee having borders within about 40 miles of ORR. The probability of a tornado striking a particular point in the vicinity of ORR is estimated to be 6.0×10^{-5} per year. The recurrence interval associated with this probability is 16,550 years (ORNL 1981a:3.3-7).

On February 21, 1993, a tornado passed through the northeastern edge of ORR and caused considerable damage to a large number of structures in the nearby Union Valley Industrial Park. Damage from this tornado to ORR was relatively light. The wind speeds associated with this tornado ranged from 40 mph to those approaching 130 mph (OR DOE 1993c:iii).

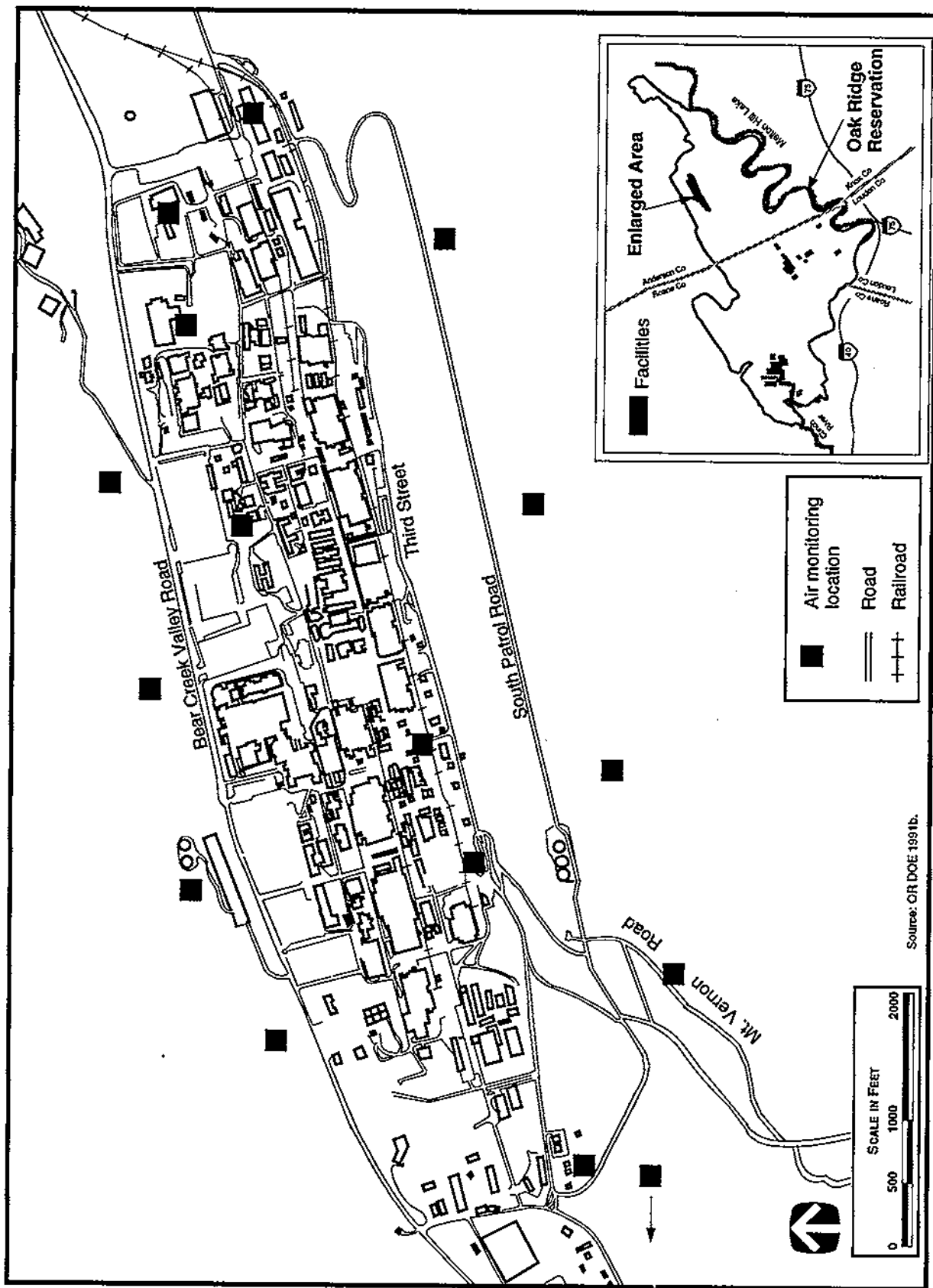
Atmospheric Dispersion Characteristics. Data collected at the ORR meteorological monitoring station (Y-12 Plant east tower) for calendar year 1990 indicate that unstable conditions occur approximately 23 percent of the time, neutral conditions approximately 31 percent, and stable conditions approximately 46 percent, on an annual basis.



Source: ORR 1991a:8.

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FIGURE B.1.3.4-1.—Wind Distribution at Oak Ridge Reservation, 1990 (98-foot level).



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FIGURE B.1.3.4-2.—Ambient Air Quality Monitoring Network at Oak Ridge Reservation, Y-12 Plant.

TABLE B.1.3.4-1.—Ambient Air Quality Data for Oak Ridge Reservation, 1990

Monitoring Station	Ambient Concentration ($\mu\text{g}/\text{m}^3$)									
	Sulfur Dioxide		Carbon Monoxide		Nitrogen Oxides		Total Suspended Particulates ^a		Particulate Matter ^{b,c}	
	Annual	Max. 24-hour	Max. 8-hour	Max. 1-hour	Annual	Max. 24-hour	Max. 24-hour	Annual	Max. 24-hour	Lead ^c Max. Calendar Quarter
Oak Ridge Reservation	27	73	d	d	d	73	73	8	54	0.05 ^e
										Max. 30-day 7-day
										0.06 0.03

^a Excludes low air flow measurements.^b Particulate matter less than 10 microns in diameter.^c Monitoring station is at K-25.^d Not monitored.^e Value is maximum for a 24-hour period.

Source: OR DOE 1991b; OR DOE 1991d.

TABLE B.1.3.4-2.—Source Emission Inventory for Oak Ridge Reservation, 1990-1992

Source	Criteria Pollutant—Emission Rate (lb/hr)				
	Carbon Monoxide	Nitrogen Oxide	Particulate Matter	Sulfur Dioxide	
Y-9401 West Stack	4.63	81.65	0.2	33.84	
Y-9401 East Stack	4.63	81.65	0.2	33.84	
K-1501 Boiler 4	0.61	2.46	0.09	0.01	
K-1501 Boiler 7	0.46	1.84	0.07	0.008	
K-1501 Boiler 8 and 9	1.97	0.74	0.13	0.008	
K-25 Toxic Substance Control Act Incinerator	—	—	2.06	0.58	
X-2519-1	9.84	27.56	1.19	176.59	
X-2519-2	1.68	27.56	1.19	176.59	
X-2519-3 and 4	—	—	0.32	0.075	

Source: OR DOE 1993a.

TABLE B.1.3.4-3.—Emission Rates and Maximum Site Boundary Concentration of Toxic/Hazardous Air Pollutants at Oak Ridge Reservation, 1992

Pollutant	Emission Rate (tons/yr)	Maximum 8-hour Average Concentration ^a ($\mu\text{g}/\text{m}^3$)	Tennessee Department of Health and Environment Standard ($\mu\text{g}/\text{m}^3$)
Chlorine	1.82	4.1	150
Chlorodifluoromethane	3.85	16.4	354,000
Dichlorodifluoromethane	3.37	10.5	495,000
Dichlorotetrafluoroethane	10.04	24.1	699,000
Hydrochloric acid	7.72	57	750
Methyl alcohol	29.11	216	26,200
Nitric acid	10.5	78	520
Sulfuric acid	2.71	20	100
Tetrachloroethylene	13.5	100	33,900
Trichloroethane	0.82	6.1	191,000
Trichlorofluoromethane	8.8	46.2	562,000
Trichlorotrifluoroethane	3.02	10.1	767,000

^a The concentrations are the maximum values at or beyond the site boundary or on public access highways.
Source: OR DOE 1993a.

TABLE B.1.3.4-4.—Estimated Ambient Concentration of Criteria Pollutants from Existing Sources at Oak Ridge Reservation, 1992

Pollutant	Averaging Time	Most Stringent Regulation or Guideline ($\mu\text{g}/\text{m}^3$)	Maximum Background Concentration ^a ($\mu\text{g}/\text{m}^3$)	ORR Contribution Concentration ^a ($\mu\text{g}/\text{m}^3$)	Baseline Concentration ^a ($\mu\text{g}/\text{m}^3$)
Carbon monoxide	8-hour	10,000	b	5	5
	1-hour	40,000	b	11	11
Lead	Calendar quarter	1.5	0.05	c	0.05
Nitrogen dioxide	Annual	100	b	3	3
Particulate matter	Annual	50	8	<1	9
	24-hour	150	54	2	56
Sulfur dioxide	Annual	80	27	2	29
	24-hour	365	73	32	105
	3-hour	1,300	321	80	401
Total suspended particulates	24-hour	150	73	2	75

^a The concentrations are the maximum values at or beyond the site boundary or on public access highways.

^b Not monitored.

^c No source indicated.

Source: 40 CFR 50; OR DHE 1991a; OR DOE 1993a.

B.1.3.5 Pantex Plant

This section provides information on meteorology and climatology, atmospheric dispersion characteristics, and annual mean wind speeds and direction frequencies at Pantex Plant (Pantex) (figure B.1.3.5-1). Air quality monitoring data and emission source inventories for criteria pollutants at Pantex are presented in tables B.1.3.5-1 and B.1.3.5-2, respectively. Emission rates and maximum site boundary concentrations of toxic/hazardous air pollutants and estimated ambient concentrations of criteria pollutants from existing sources at Pantex are presented in tables B.1.3.5-3 and B.1.3.5-4, respectively. This information supports data presented in section 4.5.2.3.

Meteorology And Climatology. Figure B.1.3.5-1 shows annual mean wind speeds and direction frequencies for 1989 measured at the 33-foot level of the Amarillo National Weather Service station near Pantex. Prevailing wind directions are from the south to southwest. The average annual wind speed measured at the Amarillo National Weather Service station is 13.6 mph. Monthly average wind speeds range from 12 mph in August to 15.4 mph in March (NOAA 1991c:3).

The average annual temperature in the Amarillo region is about 57 °F, and ranges from an average of 36 °F in January to about 78 °F in July. Relative

humidity readings taken 4 times per day range from 31 percent in April to 80 percent in September (NOAA 1991c:3).

The average annual precipitation in Amarillo is 19.1 inches (NOAA 1991c:3). Most of the annual precipitation falls during the months of April through October and usually occurs from thunderstorm activity and the intrusion of warm, moist tropical air from the Gulf of Mexico. Snowfall averages nearly 15.5 inches. Snowfall has occurred in the area from October to April. The maximum 24-hour rainfall with a 100-year recurrence interval is approximately 6.5 inches. On the average, the area can expect thunderstorms about 50 days per year, hail 4 days per year, and freezing rain 8 days per year. During the 30-year period between 1954 and 1983, a total of 107 tornadoes were reported within a 1-degree latitude and longitude square area which includes Pantex. On average, less than four tornadoes occur in an area of 3,898 square miles surrounding Pantex per year. The estimated probability of a tornado striking a point at Pantex is 2.3×10^{-4} per year (NRC 1986a:32).

Atmospheric Dispersion Characteristics. Data collected at the Amarillo National Weather Service station for 1989 indicate that unstable conditions occur approximately 16 percent of the time, neutral conditions approximately 60 percent, and stable conditions approximately 24 percent, on an annual basis.

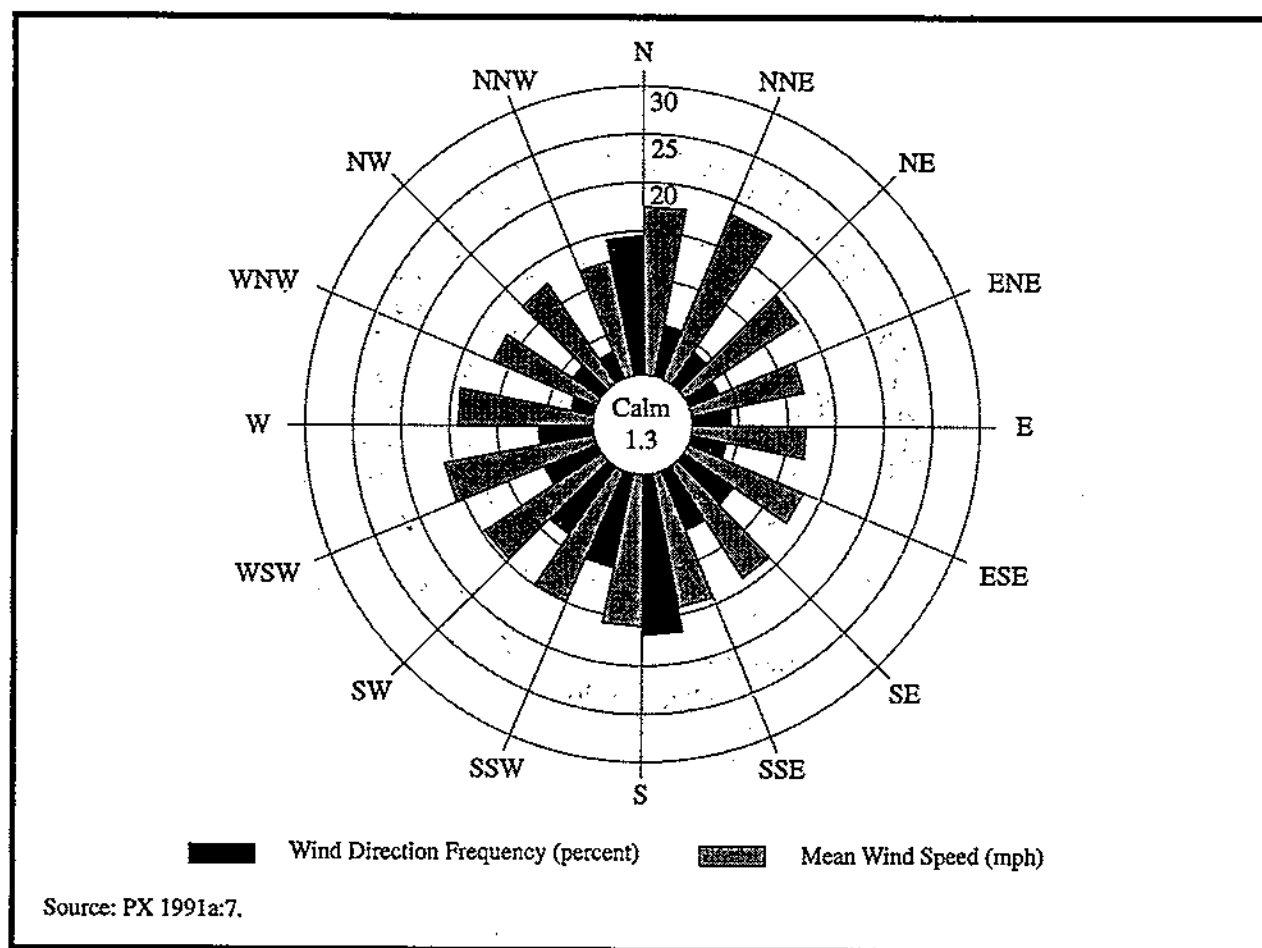


FIGURE B.1.3.5-1.—Wind Distribution at Pantex Plant, 1989 (33-foot level).

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TABLE B.1.3.5-1.—Ambient Air Quality Data for Pantex Plant, 1986-1991

Monitoring Station	Time Period	Ambient Concentration ($\mu\text{g}/\text{m}^3$)		
		Particulate Matter ^a		Lead
		Annual	Maximum 24-hour	Maximum Calendar Quarter
Bi-City-County Health Unit 417, Amarillo, TX	Jan. 1986-Apr. 1987	^b	^b	0.07
Bi-City-County Health Unit 417, Amarillo, TX	Jan. 1986-Dec. 1988	26.5 ^c	67	^b
Van Buren and 4th Street, Amarillo, TX	Jan. 1990-Dec. 1991	21.4 ^c	110	^b

^a Particulate matter less than 10 microns in diameter.

^b Not measured.

^c Indicates that the mean does not satisfy summary criteria.

Source: PX EPA 1992a.

TABLE B.1.3.5-2.—Source Emission Inventory for Pantex Plant, 1991

Source	Air Pollutant – Emission Rate (lb/hr)				
	Carbon Monoxide	Hydrogen Fluoride	Nitrogen Oxide	Particulate Matter	Sulfur Dioxide
Buildings	3.72	—	0.43	0.25	0.07
Natural gas boilers	1.77	—	7.1	0.25	0.06
Natural gas furnaces	0.13	—	0.67	0.02	—
Natural gas water heaters	0.06	—	0.28	0.01	—
Natural gas engines	2.38	—	18.46	—	—
Emergency electric generators	6.4	—	36	0.4	2.2
Diesel engines	82.64	—	352.23	25.15	23.43
Burning of high explosive wastes	4.38	—	0.21	2.42	—
Burning of high explosives	15.4	5.89	9.31	—	—
Gasoline engines	44.39	—	1.15	0.07	0.07

Source: PX 1992a:9; PX 1992a:10.

TABLE B.1.3.5-3.—Emission Rates and Maximum Site Boundary Concentration of Toxic/Hazardous Air Pollutants at Pantex Plant, 1991

Pollutant	Emission Rate (tons/yr)	Max. 1-hour Concentration ^a (µg/m ³)	Annual Average Concentration (µg/m ³)	30-minute Standard (µg/m ³) ^b	Annual Standard (µg/m ³) ^b
1,1,2-Trichloro-1,2,2-Trifluoroethane	0.11	12.6	<0.01	c	d
1,1,1-Trichloroethane	0.075	8.3	<0.01	19,100	1,910
2-Butoxyethanol	4.47	208.9	0.13	1,210	121
Acetone	6.82	341.1	0.2	5,900	590
Aliphatic hydrocarbons	0.11	19	<0.01	d	d
Aromatic hydrocarbons	0.15	27.2	<0.01	d	d
Aromatic petroleum distillate	0.08	13.6	<0.01	3,500	350
Butyl acetate ^d	0.48	87	0.01	1,850	710
Butyl alcohol ^e	0.18	31.6	0.01	1,220	150
Chlorodifluoromethane	0.1	4.9	<0.01	18,000	1,800
Cyanogen	0.26	161.8	0.01	210	21
Dichlorodifluoromethane	0.15	23.2	<0.01	49,500	4,950
Diesel fuel	0.05	2.4	<0.01	90	9
Ethyl alcohol	0.12	12.2	<0.01	18,800	1,880
Epoxy solvent	0.09	16.5	<0.01	d	d
Freon TF	0.53	24.8	0.02	d	d
Hydrocarbons	2.75	1,812	0.08	d	d
Hydrogen chloride	0.37	232.3	0.01	75	0.1
Isopropyl alcohol	0.74	127.3	0.02	7,856	980
Methyl ethyl ketone	0.53	92.8	0.02	3,900	590
Methyl alcohol	3.8	178.3	0.11	2,620	262
Methyl isobutyl ketone	0.06	5.4	<0.01	2,050	205
Tert-butyl-ether	0.18	1.9	0.01	d	d
Tetrahydrofuran	0.63	29.6	0.02	5,900	590
Toluene	4.41	236.2	0.13	3,750	375
Trichlorotrifluoroethane	0.14	7.3	<0.01	10,000	1,000
VM&P naptha	0.13	23.3	<0.01	3,500	350
Xylene	0.09	44.2	<0.01	3,700	435

^a 30-minute concentrations calculated as 1-hour concentrations.^b Texas Air Control Board Standard.^c No state standards.^d Assumed to be butyl acetate, n-^e Assumed to be butyl alcohol, n-

Source: PX 1992a:10; PX ACB 1991a.

TABLE B.1.3.5-4.—*Estimated Ambient Concentration of Pollutants
from Existing Sources at Pantex Plant, 1991*

Pollutant	Averaging Time	Most Stringent Regulation or Guideline ($\mu\text{g}/\text{m}^3$)	Maximum Background Concentration ^a ($\mu\text{g}/\text{m}^3$)	Pantex Plant Contribution Concentration ^a ($\mu\text{g}/\text{m}^3$)	Baseline Concentration ^a ($\mu\text{g}/\text{m}^3$)
Criteria Pollutant					
Carbon monoxide	8-hour	10,000	b	1,352	1,352
	1-hour	40,000	b	7,836	7,836
Lead	Quarter	1.5	0.07	c	0.07
Nitrogen dioxide	Annual	100	b	2	2
Ozone	1-hour	235	b	b	b
Particulate matter	Annual	50	26.5	0.07	27
	24-hour	150	110	4.35	114
Sulfur dioxide	Annual	80	b	0.03	0.03
	24-hour	365	b	24.33	24
	3-hour	1,300	b	194.41	194
Mandated by Texas					
Beryllium	24-hour	0.01	b	c	c
Hydrofluoric acid	30-day	0.8	b	c	c
	7-day	1.6	b	c	c
	24-hour	2.9	b	c	c
	12-hour	3.7	b	c	c

^a The concentrations are the maximum values at or beyond the site boundary.

^b Not monitored.

^c No source indicated.

Source: 40 CFR 50; PX 1992a:9; PX 1992a:10; PX ACB 1993a; PX EPA 1992a.

B.1.3.6 Savannah River Site

This section provides information on meteorology and climatology, atmospheric dispersion characteristics, annual mean wind speeds and direction frequencies (figure B.1.3.6-1), and locations of ambient air quality monitoring stations (figure B.1.3.6-2) at the Savannah River Site (SRS). Air quality monitoring data and emission source inventories for criteria pollutants at SRS are presented in tables B.1.3.6-1 and B.1.3.6-2, respectively. Emission rates and maximum site boundary concentrations of toxic/hazardous air pollutants and estimated ambient concentrations of criteria pollutants from existing sources at SRS are presented in tables B.1.3.6-3 and B.1.3.6-4, respectively. This information supports data presented in section 4.6.2.3.

Meteorology and Climatology. Figure B.1.3.6-1 shows annual mean wind speeds and direction frequencies for 1985 measured at the 200-foot level of the SRS H-Area Weather Station. The wind data from the site indicate that there is no predominant wind direction at SRS. The maximum directional frequencies are from the northeast or the west. The average annual wind speed measured is 12.8 mph. Monthly average wind speeds range from 11.2 mph from June through August, to 15.1 mph in February.

The average annual temperature at SRS is 64 °F; the average monthly range is from 45 °F in January to 81 °F in July. Relative humidity readings taken 4 times per day range from 36 percent in April to 98 percent in August.

The average annual precipitation at SRS is 48 inches. Precipitation is distributed fairly evenly throughout the year, with the highest precipitation in summer (14.2 inches) and the lowest in autumn (8.8 inches). Although snow can fall from October through March, the average annual snowfall is only 1.2 inches; large snowfalls are rare.

Winter storms in the SRS area occasionally bring strong and gusty surface winds with speeds as high as 72 mph. Thunderstorms can generate winds with speeds as high as 40 mph and even stronger gusts. The fastest 1-minute wind speed recorded at Augusta between 1950 and 1986 was 83 mph (NOAA 1991c:3).

The average number of thunderstorm days per year at SRS is 56. From 1954 to 1983, 37 tornadoes were reported for a 1-degree square of latitude and longitude that includes SRS. This frequency of occurrence amounts to an average of about one tornado per year. The estimated probability of a tornado striking a point at SRS is 7.0×10^{-5} per year (NRC 1986a:32). Since operations began at SRS in 1953, six tornadoes have been confirmed on or near SRS. Nothing more than light damage was reported in any of these storms, with the exception of a tornado in October 1989. That tornado caused considerable damage to timber resources in an undeveloped wooded area of SRS (WSRC 1990a:1).

From 1899 to 1980, 13 hurricanes occurred in Georgia and South Carolina, for an average frequency of about one hurricane every 6 years. Three hurricanes were classified as major. Because SRS is about 100 miles inland, the winds associated with hurricanes have usually diminished below hurricane force (greater than or equal to a sustained speed of 75 mph) before reaching the site (DOE 1992e:4-115).

Atmospheric Dispersion Characteristics. Data collected at the SRS meteorological monitoring station for 1985 indicate that unstable conditions occur approximately 51 percent of the time, neutral conditions approximately 27 percent of the time, and stable conditions approximately 22 percent of the time, on an annual basis.

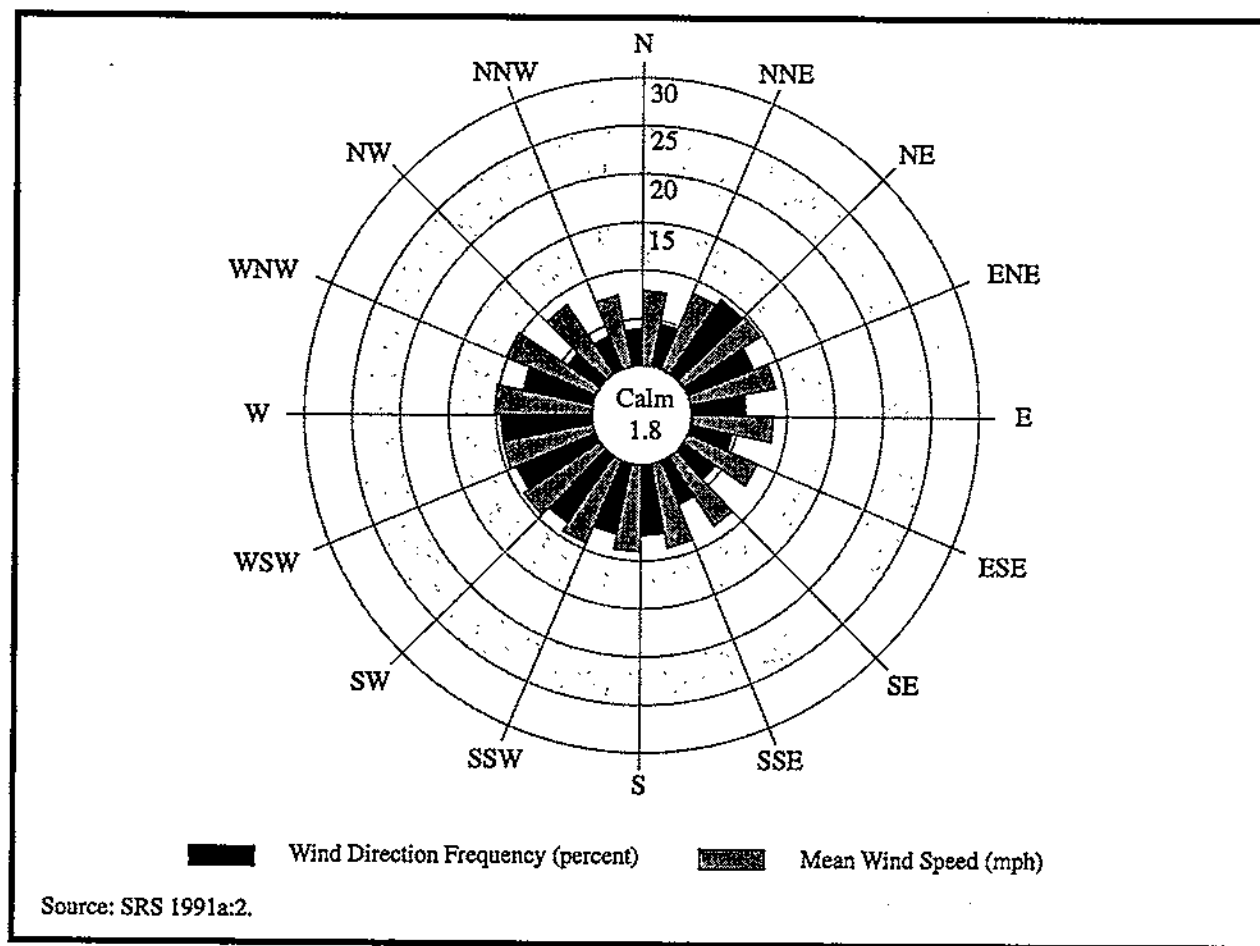


FIGURE B.1.3.6-1.—Wind Distribution at Savannah River Site, 1985 (200-foot level).

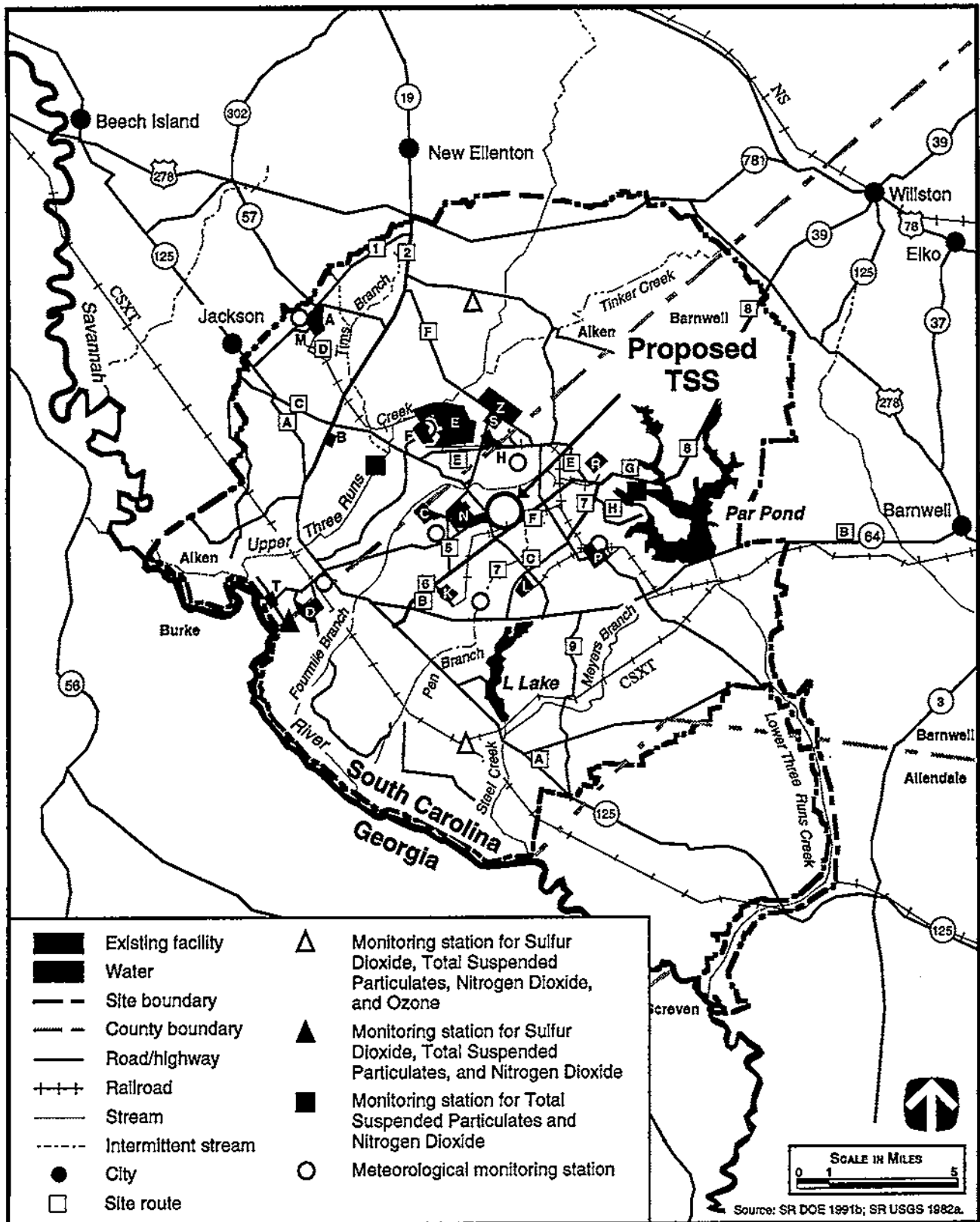


FIGURE B.1.3.6-2.—Ambient Air Quality Monitoring Network and Meteorological Stations at Savannah River Site.

TABLE B.1.3.6-1.—Ambient Air Quality Data for Savannah River Site, 1985

Monitoring Station	Ambient Concentration (µg/m ³)								
	Sulfur Dioxide			Nitrogen Oxides	Total Suspended Particulates		Particulate Matter ^a		Ozone
	Annual	Max. 24-hour	Max. 3-hour	Annual	Annual	Max. 24-hour	Annual	Max. 24-hour	Max. 1-hour
Savannah River Site	5	34	48	6	27	47	27	47	235

^a Particulate matter less than 10 microns in diameter.

Note: Carbon monoxide and lead were not measured at this site.

Source: SR NUS 1991a.

TABLE B.1.3.6-2.—Source Emission Inventory for Savannah River Site, 1987 [Page 1 of 2]

Source	Criteria Pollutant—Emission Rate									
	Carbon Monoxide		Nitrogen Oxide		Particulate Matter		Sulfur Dioxide		Area (lb/hr/ft ²)	Area (lb/hr/ft ²)
	Stack (lb/hr)	Area (lb/hr/ft ²)	Stack (lb/hr)	Area (lb/hr/ft ²)	Stack (lb/hr)	Area (lb/hr/ft ²)	Stack (lb/hr)	Area (lb/hr/ft ²)		
784-A Boiler 1	14		39.13		10.16		106.8			
784-A Boiler 2	14		39.13		10.16		106.8			
484-D Boiler 1	9.6		544.9		21.67		743			
484-D Boiler 2	9.6		544.9		21.67		743			
484-D Boiler 3	9.6		544.9		21.67		743			
484-D Boiler 4	9.6		544.9		21.67		743			
284-H Boiler 1	14		39.13		10.16		106.8			
284-H Boiler 2	14		39.13		10.16		106.8			
284-H Boiler 3	14		39.13		10.16		106.8			
184-K Boiler 1	1.1		11.98		2.7		92			
184-K Boiler 2	1.1		11.98		2.7		92			
184-P Boiler 1	1.1		11.98		2.7		92			
H Diesel Gen(2)	0.794		12.3		0.794		0.794			
F Diesel Gen(2)	0.714		9.6		0.714		0.714			
K Diesel Gen(2)	0.873		13.49		0.873		0.873			
L Diesel Gen(2)	0.873		13.49		0.873		0.873			
P Diesel Gen(2)	0.873		13.49		0.873		0.873			
Consolidated Incineration Facility	0.033		8.651							
A Source		2.8x10 ⁻⁷		6.3x10 ⁻⁶				5.0x10 ⁻⁴		1.9x10 ⁻⁶
D Source		3.8x10 ⁻⁷		8.7x10 ⁻⁶				2.1x10 ⁻⁷		2.6x10 ⁻⁶

TABLE B.1.3.6-2.—Source Emission Inventory for Savannah River Site, 1987 [Page 2 of 2]

Source	Criteria Pollutant—Emission Rate							
	Carbon Monoxide		Nitrogen Oxide		Particulate Matter		Sulfur Dioxide	
	Stack (lb/hr)	Area (lb/hr/ft ²)	Stack (lb/hr)	Area (lb/hr/ft ²)	Stack (lb/hr)	Area (lb/hr/ft ²)	Stack (lb/hr)	Area (lb/hr/ft ²)
H Source		3.3x10 ⁻⁷		7.6x10 ⁻⁶		2.5x10 ⁻⁷		2.3x10 ⁻⁶
F Source		2.8x10 ⁻⁷		6.3x10 ⁻⁶		2.1x10 ⁻⁷		1.9x10 ⁻⁶
K Source		6.1x10 ⁻⁷		1.4x10 ⁻⁵		4.6x10 ⁻⁷		4.2x10 ⁻⁶
L Source		6.3x10 ⁻⁷		1.5x10 ⁻⁵		4.8x10 ⁻⁷		4.4x10 ⁻⁶
P Source		6.7x10 ⁻⁷		1.5x10 ⁻⁵		5.0x10 ⁻⁷		4.6x10 ⁻⁶
S Source		1.3x10 ⁻⁶		2.9x10 ⁻⁵		9.5x10 ⁻⁷		8.7x10 ⁻⁶
Z Source		1.0x10 ⁻⁵		2.4x10 ⁻⁴		7.8x10 ⁻⁷		7.2x10 ⁻⁵
B source		1.1x10 ⁻⁶		2.6x10 ⁻⁵		8.4x10 ⁻⁷		7.7x10 ⁻⁶
TNX Source		3.8x10 ⁻⁶		8.8x10 ⁻⁵		2.9x10 ⁻⁶		2.6x10 ⁻⁵
C Source		5.9x10 ⁻⁷		1.4x10 ⁻⁵		4.4x10 ⁻⁷		4.1x10 ⁻⁶
CS Source		5.7x10 ⁻⁷		1.3x10 ⁻⁵		4.3x10 ⁻⁷		3.9x10 ⁻⁶
F Pu Separation			137					
H H3 Separation			6.826					
M Air Stripper			2.302					
Defense Waste Processing Facility Nitrate Process			8.413					
S Concrete Batch					45.4			
D Coal Pile Top						1.9x10 ⁻⁶		
D Coal Pile Bottom						3.9x10 ⁻⁶		
P Coal Pile						1.7x10 ⁻⁶		
K Coal Pile						2.2x10 ⁻⁶		
F Coal Pile						1.8x10 ⁻⁶		
H Coal Pile						1.1x10 ⁻⁶		
A Coal Pile						2.6x10 ⁻⁶		
D Area Coal Crush						8.7x10 ⁻⁴		
D Coal Handling Top						1.6x10 ⁻⁷		
D Coal Handling Bottom						3.5x10 ⁻⁷		
P Coal Handling						1.6x10 ⁻⁷		
K Coal Handling						2.0x10 ⁻⁷		
F Coal Handling						1.6x10 ⁻⁷		
N Coal Handling						9.5x10 ⁻⁸		
A Coal Handling						2.3x10 ⁻⁷		

Source: SR NUS 1991a.

TABLE B.1.3.6-3.—Emission Rates and Maximum Site Boundary Concentration of Toxic/Hazardous Air Pollutants at Savannah River Site, 1990

Pollutant	Emission Rate (tons/yr)	Maximum 24-hour Average Concentration ($\mu\text{g}/\text{m}^3$)	Proposed South Carolina Ambient Standard ($\mu\text{g}/\text{m}^3$) ^a
Nitric acid	9.5	3.2	125
1,1,1-Trichloroethane	10.7	3.6	9,550
Trichlorotrifluoroethane	5.5	1.8	^b

^a 24-hour average concentration.

^b No state standard has been proposed.

Source: SR DHEC 1991a; SR NUS 1991a.

TABLE B.1.3.6-4.—Estimated Ambient Concentration of Criteria Pollutants from Existing Sources at Savannah River Site, 1987

Pollutant	Averaging Time	Most Stringent Regulations or Guidelines ($\mu\text{g}/\text{m}^3$)	Maximum Background Concentration ^{a,b} ($\mu\text{g}/\text{m}^3$)	SRS Contribution Concentration ^a ($\mu\text{g}/\text{m}^3$)	Baseline Concentration ^a ($\mu\text{g}/\text{m}^3$)
Carbon monoxide	8-hour	10,000	^c	38	38
	1-hour	40,000	^c	154	154
Lead	Calendar Quarter	1.5	^c	^d	^d
Nitrogen dioxide	Annual	100	6	16	22
Ozone	1-hour	235	235	0	235
Particulate matter ^e	Annual	50	27	1	28
	24-hour	150	47	17	64
Sulfur dioxide	Annual	80	5	11	16
	24-hour	365	34	232	266
	3-hour	1,300	48	1,074	1,122
Total suspended particulates	Annual	75	27	2	29

^a The concentrations are the maximum values at or beyond the site boundary.

^b Ambient air quality monitoring data for 1989-1990 (table B.1.3.6-1).

^c Not monitored.

^d No source indicated.

^e It is assumed that all particulate matter concentrations are total suspended particulate concentrations.
Source: 40 CFR 50; DOE 1992h; SR NUS 1991a; SR DHEC 1992b.

B.1.4 Environmental Impacts

Major sources of air pollutant emissions for each of the proposed actions at each site during construction and operation are described in sections 4.2.3.3, 4.3.3.3, 4.4.3.3, 4.5.3.3, and 4.6.3.3. The *Environmental and Other Evaluations of Alternatives for Siting, Constructing, and Operating New Production Reactor Capacity* (DOE/NP-0014) contains an analysis for sources due to construction of New Production Reactor capability. The analysis was performed for each of three tritium supply technologies: Modular High Temperature Gas-Cooled Reactor (MHTGR), Light Water Reactor, and Heavy Water Reactor (HWR); which involves facilities considerably larger than those proposed for any of the technologies in this PEIS. The size of each of the tritium supply technologies proposed for each of the five candidate sites (INEL, NTS, ORR, Pantex, and SRS) is 3/8 of a full-sized New Production Reactor (DOE 1992h). The Industrial Source Complex Short-Term model and conservative modeling assumptions were also used and performed in accordance with EPA's *Guideline on Air Quality Models* (EPA-450/2-78-027R) for the *Environmental and Other Evaluations of Alternatives for Siting, Constructing, and Operating New Production Reactor Capacity* (DOE/NP-0014). Resulting impacts for each of the "full-sized" tritium supply technologies were calculated to be less than applicable standards.

For the purposes of this PEIS, it is considered that emissions from construction activities related to the proposed actions would be transitory in nature. It is expected that particulate matter of aerodynamic diameter less than 10 micrometers (PM_{10}) and/or total suspended particulates (TSP) concentrations would be close to or exceed the 24-hour ambient

standards during the peak construction period. These emissions would result from construction activities involving various heavy duty equipment, fuel usage from their operation, and emissions from increased traffic. This potential exceedance is typical of conditions that can occur for projects the size of this proposed action and would generally occur during dry and windy conditions. Appropriate mitigative actions would be followed, such as increased watering, to lower emissions. It is expected that, except for these potential transitory PM_{10} and/or TSP exceedances, all ambient concentrations of criteria and toxic pollutants at, or beyond, each of the site boundaries would remain below applicable national and state ambient air quality standards. Consequently, no emissions inventory is provided for the construction sources.

Potential ambient air quality impacts of the emissions due to operation of each of the tritium supply technologies and recycling facilities at each site were analyzed using the Industrial Source Complex Short-Term computer code described in section B.1.2. The model input data include the emission inventories for the baseline and operation sources for each of the tritium supply technologies and recycling facilities. Emissions from the Large ALWR were used to determine pollutant concentrations since these represent the maximum emission rates from either the Large or Small ALWR. Tables B.1.4-1 through B.1.4-5 provide the emissions inventory at the sites considered for the potential receipt of the tritium supply and recycling facilities and for those sources considered to have a potential impact on ambient air quality related to the action. Tables 4.2.3.3-1, 4.3.3.3-1, 4.4.3.3-1, 4.5.3.3-1, and 4.6.3.3-1 provide a summary of the potential ambient air quality impacts from these sources.

TABLE B.1.4-1.—Potential Air Emissions Resulting from Tritium Supply Technologies and Recycling
at Idaho National Engineering Laboratory (tons/year) [Page 1 of 2]

Criteria Pollutant	Pollutant	2010 No Action	Tritium Supply Technologies and Recycling					Tritium Recycling
			HWR	MHTGR	ALWR	APT		
Carbon monoxide		2,425	11.50	39.00	14.50	4.50	4.50	
Nitrogen dioxide		3,307	21.00	55.50	48.00	6.00	6.00	
Particulate matter ^a		992	3.30	1.72	2.30	1.45	1.45	
Sulfur dioxide		1,874	0.34	0.26	0.66	0.11	0.11	
Total suspended particulates ^a		992	3.30	1.72	2.30	1.45	1.45	
Volatile organic compounds		90	1.60	0.94	6.15	0.65	0.65	
Hazardous and Other Toxic Compounds								
1,1,1-Trichloroethane		b	0.20	0.065	4.60	b	b	
Acetaldehyde		0.20	b	b	b	b	b	
Acetone		b	b	b	2.00	b	b	
Acetylene		b	0.64	0.64	0.64	0.64	0.64	
Ammonia		7.16	b	b	1.05	b	b	
Arsenic		0.03	b	b	b	b	b	
Benzene		0.58	b	b	b	b	b	
Butadiene		0.43	b	b	b	b	b	
Carbon tetrachloride		0.03	b	b	b	b	b	
Chloroform		0.002	b	b	b	b	b	
Cyclopentane		0.39	b	b	b	b	b	
Ethyl alcohol		b	0.24	0.24	0.24	0.24	0.24	
Formaldehyde		3.64	b	b	b	b	b	
Hexavalent chromium		0.03	b	b	b	b	b	
Hydrazine		0.01	b	b	b	b	b	
Hydrochloric acid		1.65	b	b	b	b	b	
Mercury		0.22	b	b	b	b	b	
Methane		b	0.64	0.64	0.64	0.64	0.64	
Methyl alcohol		b	0.24	0.24	0.24	0.24	0.24	
Methylene chloride		1.21	b	b	b	b	b	
Naphalene		0.02	b	b	b	b	b	

TABLE B.1.4-1.—Potential Air Emissions Resulting from Tritium Supply Technologies and Recycling
at Idaho National Engineering Laboratory (tons/year) [Page 2 of 2]

Pollutant	2010 No Action	Tritium Supply Technologies and Recycling				
		HWR	MHTGR	ALWR	APT	Tritium Recycling
Hazardous and Other Toxic Compounds (Continued)						
Nickel	1.1	b	b	b	b	b
Nitric acid	106.92	1.2	b	14	b	b
Perchloroethylene	1.08	b	b	b	b	b
Phosphorus	0.23	b	b	b	b	b
Potassium hydroxide	2.31	b	b	b	b	b
Propionaldehyde	0.12	b	b	b	b	b
Styrene	0.01	b	b	b	b	b
Toluene	0.64	b	b	b	b	b
Trichloroethylene	0.005	b	b	b	b	b
Trichlorotrifluoroethane	b	8.5	b	b	b	b
Trimethylbenzene	0.1	b	b	b	b	b
Trivalent chromium	0.04	b	b	b	b	b

^a It is conservatively assumed that all particulate matter emissions are total suspended particulate emissions.

^b No sources indicated.

Note: To calculate emissions from tritium supply technologies only, subtract corresponding pollutant emissions of tritium recycling from tritium supply and recycling emissions.
Source: DOE 1995d, DOE 1995e, DOE 1995g; SNL 1995a.

TABLE B.1.4-2.—Potential Air Emissions Resulting from Tritium Supply Technologies and Recycling at Nevada Test Site (tons/year)

Pollutant	2010 No Action	Tritium Supply Technologies and Recycling				
		HWR	MHTGR	ALWR	APT	Tritium Recycling
Criteria Pollutant						
Carbon monoxide	5	11.5	39	14.5	4.5	4.5
Nitrogen dioxide	41	21	55.5	48	6	6
Particulate matter ^a	26	3.3	1.72	2.3	1.45	1.45
Sulfur dioxide	20	0.34	0.26	0.66	0.11	0.11
Total suspended particulates ^a	26	3.3	1.72	2.3	1.45	1.45
Volatile organic compounds	b	1.6	0.94	6.15	0.65	0.65
Hazardous and Other Toxic Compounds						
1,1,1-Trichloroethane	b	0.2	0.065	4.6	b	b
Acetone	b	b	b	2	b	b
Acetylene	b	0.64	0.64	0.64	0.64	0.64
Ammonia	b	b	b	1.05	b	b
Ethyl alcohol	b	0.24	0.24	0.24	0.24	0.24
Methane	b	0.64	0.64	0.64	0.64	0.64
Methyl alcohol	b	0.24	0.24	0.24	0.24	0.24
Nitric acid	b	1.2	b	14	b	b
Trichlorotrifluoroethane	b	8.5	b	b	b	b

^a It is conservatively assumed that all particulate matter emissions are total suspended particulate emissions.

^b No sources indicated.

Note: To calculate emissions from tritium supply technologies only, subtract corresponding pollutant emissions of tritium recycling from tritium supply and recycling emissions.
Source: DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; NTS 1993a:4.

TABLE B.1.4-3.—Potential Air Emissions Resulting from Tritium Supply Technologies and Recycling at Oak Ridge Reservation (tons/year)

Pollutant	2010 No Action	Tritium Supply Technologies and Recycling				Tritium Recycling
		HWR	MHTGR	ALWR	APT	
Criteria Pollutant						
Carbon monoxide	104	11.5	39	14.5	4.5	4.5
Nitrogen dioxide	960	21	55.5	48	6	6
Particulate matter ^a	20	3.3	1.72	2.3	1.45	1.45
Sulfur dioxide	1,070	0.34	0.26	0.66	0.11	0.11
Total suspended particulates ^a	20	3.3	1.72	2.3	1.45	1.45
Volatile organic compounds	4	1.6	0.94	6.15	0.65	0.65
Hazardous and Other Toxic Compounds						
1,1,1-Trichloroethane	0.82	0.2	0.065	4.6	b	b
Acetone	b	b	b	2	b	b
Acetylene	b	0.64	0.64	0.64	0.64	0.64
Ammonia	b	b	b	1.05	b	b
Chlorine	1.82	b	b	b	b	b
Chlorodifluoromethane	3.85	b	b	b	b	b
Dichlorodifluoromethane	3.37	b	b	b	b	b
Ethyl alcohol	b	0.24	0.24	0.24	0.24	0.24
Hydrogen chloride	7.72	b	b	b	b	b
Methane	b	0.64	0.64	0.64	0.64	0.64
Methyl alcohol	29.11	0.24	0.24	0.24	0.24	0.24
Nitric acid	10.5	1.2	b	14	b	b
Sulfuric acid	2.71	b	b	b	b	b
Tetrachloroethylene	13.5	b	b	b	b	b
Trichlorofluoromethane	8.8	b	b	b	b	b
Trichlorotrifluoroethane	3.02	8.5	b	b	b	b

^a It is conservatively assumed that all particulate matter emissions are total suspended particulate emissions.

^b No sources indicated.

Note: To calculate emissions from tritium supply technologies only, subtract corresponding pollutant emissions of tritium recycling from tritium supply and recycling emissions.

Source: DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; ORR 1993a:8.

TABLE B.1.4-4.—Potential Air Emissions Resulting from Tritium Supply Technologies and Recycling at Pantex Plant (tons/year)

Pollutant	2010 No Action	Tritium Supply Technologies and Recycling				Tritium Recycling
		HWR	MHTGR	ALWR	APT	
Criteria Pollutant						
Carbon monoxide	17	11.5	39	14.5	4.5	4.5
Nitrogen Dioxide	50	21	55.5	48	6	6
Particulate Matter ^a	2.3	3.3	1.72	2.3	1.45	1.45
Sulfur Dioxide	1	0.34	0.26	0.66	0.11	0.11
Volatile Organic Compounds	14	1.6	0.94	6.15	0.65	0.65
Hazardous and Other Toxic Compounds						
1,1,1-Trichloroethane	0.075	0.2	0.065	4.6	b	b
1,1,2-Trichloro- 1,2,2-Trifluoroethane	0.11	b	b	b	b	b
2-Butoxyethanol	4.47	b	b	b	b	b
Acetone	6.82	b	b	2	b	b
Acetylene	b	0.64	0.64	0.64	0.64	0.64
Ammonia	b	b	b	1.05	b	b
Aliphatic hydrocarbons	0.11	b	b	b	b	b
Aromatic hydrocarbons	0.15	b	b	b	b	b
Aromatic petroleum distillate	0.08	b	b	b	b	b
Butyl acetate	0.48	b	b	b	b	b
Butyl alcohol	0.18	b	b	b	b	b
Chlorodifluoromethane	0.1	b	b	b	b	b
Cyanogen	0.26	b	b	b	b	b
Dichlorodifluoromethane	0.15	b	b	b	b	b
Diesel fuel	0.05	b	b	b	b	b
Ethyl alcohol	0.12	0.24	0.24	0.24	0.24	0.24
Epoxy solvent	0.09	b	b	b	b	b
Freon TF	0.53	b	b	b	b	b
Hydrocarbons	2.75	b	b	b	b	b
Hydrogen chloride	0.37	b	b	b	b	b
Hydrogen fluoride	0.46	b	b	b	b	b
Isopropyl alcohol	0.74	b	b	b	b	b
Methane	b	0.64	0.64	0.64	0.64	0.64
Methyl alcohol	3.8	0.24	0.24	0.24	0.24	0.24
Methyl ethyl ketone	0.53	b	b	b	b	b
Methyl isobutyl ketone	0.06	b	b	b	b	b
Nitric acid	b	1.2	b	14	b	b
Tert-butyl-ether	0.18	b	b	b	b	b
Tetrahydrofuran	0.63	b	b	b	b	b
Toluene	3.37	b	b	b	b	b
Trichlorotrifluoroethane	0.14	8.5	b	b	b	b
VM&P naptha	0.13	b	b	b	b	b
Xylene	0.09	b	b	b	b	b

^a It is conservatively assumed that all particulate matter emissions are total suspended particulate emissions.

^b No sources indicated.

Note: To calculate emissions from tritium supply technologies only, subtract corresponding pollutant emissions of tritium recycling from tritium supply and recycling emissions.

Source: DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; PX 1993a:2.

TABLE B.1.4-5.—Potential Air Emissions Resulting from Tritium Supply Technologies and Upgraded Recycling at Savannah River Site (tons/year) [Page 1 of 2]

Pollutant	Tritium Supply Technologies and Recycling Upgrade					Tritium Recycling Upgrade	Tritium Recycling Phaseout
	2010 No Action	HWR	MHTGR	ALWR	APT		
Criteria Pollutant							
Carbon monoxide	462	21	48.5	24	14	14	(0.43)
Nitrogen dioxide	3,129	55.55	90	82.5	40.5	40.5	(1.96)
Particulate matter ^a	531	20.85	19.27	19.85	19	19	(0.14)
Sulfur dioxide	6,915	80.23	80.16	80.55	80	80	(0.13)
Total suspended particulates ^a	1,021	1.95	0.37	0.95	0.1	0.1	^b
Volatile organic compounds	^b	1.25	0.59	5.8	0.3	0.3	^b
Hazardous and Other Toxic Compounds							
1,1,1-Trichloroethane	1.2	0.2	0.065	^b	4.6	^b	^b
1,1,2-Trichloro-1,2,2-Trifluoroethane	0.08	^b	^b	^b	^b	^b	^b
2,4-Dinitrotoluene	1	^b	^b	^b	^b	^b	^b
Acetone	^b	^b	^b	2	^b	^b	^b
Acetylene	^b	0.58	0.58	0.58	0.58	0.58	^b
Acrolein	0.08	^b	^b	^b	^b	^b	^b
Acrylonitrile	0.08	^b	^b	^b	^b	^b	^b
Ammonia	^b	^b	^b	1.05	^b	^b	^b
Antimony	0.05	^b	^b	^b	^b	^b	^b
Benzene	124	^b	^b	^b	^b	^b	^b
Cadmium	0.05	^b	^b	^b	^b	^b	^b
Cadmium oxide	0.06	^b	^b	^b	^b	^b	^b
Chlorine	6.54	^b	^b	^b	^b	^b	^b
Diethyl phthalate	0.12	^b	^b	^b	^b	^b	^b
Ethyl alcohol	^b	0.21	0.21	0.21	0.21	0.21	^b
Ethyl benzene	1.17	^b	^b	^b	^b	^b	^b
Ethyl glycol	0.44	^b	^b	^b	^b	^b	^b
Formic acid	1.6	^b	^b	^b	^b	^b	^b
Hexane	0.22	^b	^b	^b	^b	^b	^b
Hydrogen chloride	155	^b	^b	^b	^b	^b	^b
Hydrogen sulfide	4.53	^b	^b	^b	^b	^b	^b
Manganese	0.34	^b	^b	^b	^b	^b	^b
Mercury	0.17	^b	^b	^b	^b	^b	^b
Methane	^b	0.58	0.58	0.58	0.58	0.58	^b
Methyl alcohol	0.35	0.21	0.21	0.21	0.21	0.21	(0.007)
Methyl ethyl ketone	4.41	^b	^b	^b	^b	^b	(0.005)
Methyl isobutyl ketone	2.28	^b	^b	^b	^b	^b	^b
Methyl tert-butyl ether	1.71	^b	^b	^b	^b	^b	^b
Methylene chloride	1.19	^b	^b	^b	^b	^b	^b

TABLE B.1.4-5.—Potential Air Emissions Resulting from Tritium Supply Technologies and Upgraded Recycling at Savannah River Site (tons/year) [Page 2 of 2]

Pollutant	2010 No Action	Tritium Supply Technologies and Recycling Upgrade				Tritium Recycling Upgrade	Tritium Recycling Phaseout
		HWR	MHTGR	ALWR	APT		
Hazardous and Other Toxic Compounds (Continued):							
Nickel	0.24	b	b	b	b	b	b
Nickel oxide	0.05	b	b	b	b	b	b
Nitric acid	2.59	1.2	b	14	b	b	b
Sodium hydroxide	0.35	b	b	b	b	b	b
Sulfuric acid	0.05	b	b	b	b	b	b
Tetrachloroethylene	28.8	b	b	b	b	b	b
Toluene	1.55	b	b	b	b	b	(0.007)
Trichloroethylene	9.8	b	b	b	b	b	b
Trichloromethane	28.3	b	b	b	b	b	b
Trichlorotrifluoroethane	b	8.5	b	b	b	b	b
Xylene	20.6	b	b	b	b	b	(0.011)

^a It is conservatively assumed that all particulate matter emissions are total suspended particulate emissions.

^b No source indicated.

Note: To calculate emissions from tritium supply technologies only, subtract corresponding pollutant emissions of tritium upgrade from tritium supply and upgraded recycling emissions.

Note: Numbers in parenthesis indicate a net reduction in emissions.

Source: DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; SR DOE 1995a; SR NUS 1991a; SRS 1993a:3.

B.2 ACOUSTICS

B.2.1 Introduction

This section provides a summary of local noise regulations. A qualitative discussion of construction and operation noise sources and the potential for noise impacts is provided in PEIS section 4.X.2 affected environment and 4.X.3 environmental impacts. Further analysis of construction and operation noise impacts, including traffic noise impacts and impacts from outside sources, has been deferred to the tiered, site-specific NEPA documents.

The Occupational Safety and Health Administration (OSHA) standards for occupational noise exposure (29 CFR 1910) are applicable for worker protection at the site, as discussed in section 5.5.

B.2.2 Supporting Data

This section provides a discussion of local noise regulations and presents any available sound level monitoring data for the sites. There are no community noise regulations applicable to INEL, NTS, and Pantex.

B.2.2.1 Oak Ridge Reservation

Maximum allowable noise limits for the city of Oak Ridge are presented in table B.2.2.1-1.

TABLE B.2.2.1-1.—City of Oak Ridge Maximum Allowable Noise Limits Applicable to Oak Ridge Reservation

Adjacent Use	Where Measured	Maximum Sound Level (dBA)
All residential districts	Common lot line	50
Neighborhood business district	Common lot line	55
General business district	Common lot line	60
Industrial district	Common lot line	65
Major street	Street lot line	75
Secondary residential street	Street lot line	60

Source: OR City 1985a.

B.2.2.2 Savannah River Site

Ambient sound level data collected at SRS in 1989 and 1990 are summarized in *Sound-Level Characterization of the Savannah River Site* (SR NUS 1990a). The States of Georgia and South Carolina, and the counties where SRS is located, have not yet established noise regulations that specify acceptable community noise levels except for a provision of the Aiken County Nuisance Ordinance which limits daytime and nighttime noise by frequency band (table B.2.2.2-1).

TABLE B.2.2.2-1.—Aiken County Maximum Allowable Noise Levels^a

Frequency Band (Hz)	Nighttime (9:00 p.m. - 7:00 a.m.) Sound Pressure Levels (dB)	
	Nonresidential Lot Line	Residential Lot Line
20 - 75	69	65
75 - 150	60	50
150 - 300	56	43
300 - 600	51	38
600 - 1,200	42	33
1,200 - 2,400	40	30
2,400 - 4,800	38	28
4,800 - 10,000	35	20

^a Daytime (7:00 a.m. - 9:00 p.m.) sound pressure levels: apply one of the following corrections (dB) to the nighttime levels above: daytime operation only, +5; source operates less than 20 percent of any 1-hour period, +5; source operates less than 5 percent of any 1-hour period, +10; source operates less than 1 percent of any 1-hour period, +15; noise of impulsive character, -5; noise of periodic character, -5

Source: SR County 1991a.

APPENDIX C

Appendix C

APPENDIX C: BIOTIC RESOURCES

This appendix includes tables which contain the scientific names of common, nonthreatened, and nonendangered plant and animal species found in the text. Additionally, tables are presented listing flora and fauna identified by the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service, and state governments as threatened, endangered, or other special status. Special status species include Federal candidate species (Category 1 and 2) and state classifications such as species of concern, state sensitive species, monitor species, or species in need of management. Flora and fauna designated Category 3 by the Federal government are not listed in the tables

because they are no longer under consideration for possible addition to the list of threatened and endangered species. The threatened, endangered, and special status lists include all such species which could potentially occur in a site area regardless of their residence status (i.e., breeding, year round, summer, winter, or migratory) or likelihood of being affected by the tritium supply and recycling facilities. By comparison, species listed in the affected environment sections in chapter 4 are those species that are likely to be found in site areas which may be affected by the tritium supply and recycling facilities. All tables list species in alphabetical order by common name.

TABLE C-1.—Scientific Names of Common Nonthreatened and Nonendangered Plant and Animal Species Referred to in the Text [Page 1 of 2]

Common Name	Scientific Name	Common Name	Scientific Name	Common Name	Scientific Name	Common Name	Scientific Name
Mammals		Mammals		Birds		Reptiles	
(Continued)		(Continued)		(Continued)			
Badger	<i>Taxidea taxus</i>	Pronghorn	<i>Antilocapra americana</i>	Golden eagle	<i>Aquila chrysaetos</i>	Banded gecko	<i>Coleonyx variegatus</i>
Black-tailed jackrabbit	<i>Lepus californicus</i>	Raccoon	<i>Procyon lotor</i>	- Great horned owl	<i>Bubo virginianus</i>	Box turtle	<i>Terrapene carolina</i>
Black-tailed prairie dog	<i>Cynomys ludovicianus</i>	Round-tailed ground squirrel	<i>Spermophilus tereticaudus</i>	Horned lark	<i>Eremophila alpestris</i>	Desert iguana	<i>Dipsosaurus dorsalis</i>
Bobcat	<i>Lynx rufus</i>	Townsend's ground squirrel	<i>Spermophilus townsendii</i>	Mourning dove	<i>Zenaidura macroura</i>	Eastern garter snake	<i>Thamnophis sirtalis</i>
Coyote	<i>Canis latrans</i>	White-footed mouse	<i>Peromyscus leucopus</i>	Northern cardinal	<i>Cardinalis cardinalis</i>	Gopher snake	<i>Pituophis melanoleucus</i>
Eastern cottontail	<i>Sylvilagus floridanus</i>	Whitetail deer	<i>Odocoileus virginianus</i>	Northern harrier	<i>Circus cyaneus</i>	Short-horned lizard	<i>Phrynosoma douglassi</i>
Elk	<i>Cervus elaphus</i>	Birds		Prairie falcon	<i>Falco mexicanus</i>	Side-blotched lizard	<i>Uta stansburiana</i>
Feral hog	<i>Sus scrofa</i>	American kestrel	<i>Falco sparverius</i>	Red-tailed hawk	<i>Buteo jamaicensis</i>	Western shovel-nosed snake	<i>Chionactis occipitalis</i>
Gray fox	<i>Urocyon cinereoargenteus</i>	Black vulture	<i>Coragyps atratus</i>	Roadrunner	<i>Geococcyx californianus</i>	Amphibians	
Great Basin pocket mouse	<i>Perognathus parvus</i>	Black-throated sparrow	<i>Amphispiza bilineata</i>	Rough-legged hawk	<i>Buteo lagopus</i>	American toad	<i>Bufo americanus</i>
Hispid cotton rat	<i>Sigmodon hispidus</i>	Bobwhite quail	<i>Colinus virginianus</i>	Sage grouse	<i>Centrocercus urophasianus</i>	Slimy salamander	<i>Plethodon glutinosus</i>
Long-tailed weasel	<i>Mustela frenata</i>	Burrowing owl	<i>Athene cunicularia</i>	Sage sparrow	<i>Amphispiza belli</i>	Fishes	
Merriam's kangaroo rat	<i>Dipodomys merriami</i>	Carolina chickadee	<i>Parus carolinensis</i>	Scated quail	<i>Callipepla squamata</i>	American shad	<i>Alosa sapidissima</i>
Mink	<i>Mustela vison</i>	Common crow	<i>Corvus brachyrhynchos</i>	Turkey vulture	<i>Cathartes aura</i>	Banded sculpin	<i>Cottus caroliniae</i>
Mountain lion	<i>Felis concolor</i>	Cooper's hawk	<i>Accipiter cooperii</i>	Western meadowlark	<i>Sturnella neglecta</i>	Black crappie	<i>Pomoxis nigromaculatus</i>
Mule deer	<i>Odocoileus hemionus</i>	Gambel's quail				Blacknose dace	<i>Rhinichthys atratulus</i>

TABLE C-1.—Scientific Names of Common Nonthreatened and Nonendangered Plant and Animal Species Referred to in the Text [Page 2 of 2]

Common Name	Scientific Name	Common Name	Scientific Name	Common Name	Scientific Name	Common Name	Scientific Name
Fishes (continued)		Fishes (continued)		Plants (continued)		Plants (continued)	
Bluegill	<i>Lepomis macrochirus</i>	Rock bass	<i>Ambloplites rupestris</i>	Desert thorn	<i>Lycium shockleyi</i>	Rabbitbrush	<i>Chrysothamnus</i> spp.
Bluntnose minnow	<i>Pimephales notatus</i>	Sauger	<i>Stizostedion canadense</i>	Giant wildcye	<i>Elymus condensatus</i>	Red brome	<i>Bromus rubens</i>
Bream	<i>Lepomis</i> spp.	Shorthead sculpin	<i>Cottus confusus</i>	Gray horsebrush	<i>Tetradymia canescens</i>	Russian thistle	<i>Salsola kali</i>
Bullhead	<i>Ictalurus</i> spp.	Speckled dace	<i>Rhinichthys osculus</i>	Green rabbitbrush	<i>Chrysothamnus Greenei</i>	Sagebrush	<i>Artemisia</i> spp.
Central stoneroller	<i>Camptostoma anomalum</i>	Striped bass	<i>Morone saxatilis</i>	Hemlock	<i>Tsuga canadensis</i>	Salbush	<i>Atriplex</i> spp.
Crappie	<i>Pomoxis</i> spp.	Sunfish	<i>Lepomis</i> spp.	Hickory	<i>Carya</i> spp.	Shortleaf pine	<i>Pinus echinata</i>
Creek chub	<i>Semotilus atromaculatus</i>	Plants		Hopsage	<i>Grayia spinosa</i>	Side oats grama	<i>Bouteloua curtipendula</i>
Golden shiner	<i>Notemigonus crysoleucas</i>	Bald cypress	<i>Taxodium distichum</i>	Indian ricegrass	<i>Oryzopsis hymenoides</i>	Slash pine	<i>Pinus elliotii</i>
Goldfish	<i>Carassius auratus</i>	Big sagebrush	<i>Artemisia tridentata</i>	Juniper	<i>Juniperus</i> spp.	Thickspeike wheatgrass	<i>Agropyron dasyachyum</i>
Hickory shad	<i>Alosa mediocris</i>	Blackbrush	<i>Coleogyne ramosissima</i>	Little bluestem	<i>Schizachyrium scoparium</i>	Threatip sagebrush	<i>Artemisia tripartita</i>
Kokanee salmon	<i>Oncorhynchus nerka</i>	Blue grama	<i>Bouteloua gracilis</i>	Loblolly pine	<i>Pinus taeda</i>	Tupelo	<i>Nyssa sylvatica</i>
Lake chubsucker	<i>Erimyzon sucetta</i>	Bluebunch wheatgrass	<i>Agropyron spicatum</i>	Longleaf pine	<i>Pinus taeda</i>	Utah juniper	<i>Juniperus osteosperma</i>
Largemouth bass	<i>Micropterus salmoides</i>	Bottlebrush squirreltail	<i>Sitanion hystrix</i>	Low sagebrush	<i>Artemisia arbuscula</i>	Virginia pine	<i>Pinus virginiana</i>
Mosquitofish	<i>Gambusia affinis</i>	Buffalo-grass	<i>Buchloe dactyloides</i>	Needle-and-thread grass	<i>Stipa comata</i>	Western wheatgrass	<i>Agropyron smithii</i>
Mountain whitefish	<i>Prosopium williamsoni</i>	Cheatgrass	<i>Bromus tectorum</i>	Oak	<i>Quercus</i> spp.	White pine	<i>Pinus strobus</i>
Mud sunfish	<i>Acantharchus pomotis</i>	Cottonwood	<i>Populus</i> spp.	Pine	<i>Pinus</i> spp.	Willow	<i>Salix</i> spp.
Pickrel	<i>Esox</i> spp.	Creosote bush	<i>Larrea tridentata</i>	Pinyon pine	<i>Pinus edulis</i>	Winterfat	<i>Ceratoides lanata</i>
Redbreast sunfish	<i>Lepomis auritus</i>	Crested wheatgrass	<i>Agropyron desertorum</i>	Poverty-weed	<i>Monolepis nuttalliana</i>		
Redfin pickerel	<i>Esox americanus</i>	Desert thorn	<i>Lycium pallidum</i>	Prickly pear cactus	<i>Opuntia</i> spp.		

TABLE C-2.—Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found On the Site or In the Vicinity of Idaho National Engineering Laboratory

Common Name	Scientific Name	Status ^a	
		Federal	State
Mammals			
California myotis	<i>Myotis californicus</i>	C2	NL
Fringed myotis	<i>Myotis thysanodes</i>	NL	SSC
Pygmy rabbit	<i>Brachylagus idahoensis</i>	C2	NL
Townsend's western big-eared bat	<i>Plecotus townsendii townsendii</i>	C2	SSC
Western pipistrelle	<i>Pipistrellus hesperus</i>	NL	SSC
Birds			
American white pelican	<i>Pelecanus erythrorhynchos</i>	NL	SSC
Bald eagle ^b	<i>Haliaeetus leucocephalus</i>	T	T
Common loon	<i>Gavia immer</i>	NL	SSC
Ferruginous hawk ^c	<i>Buteo regalis</i>	C2	SSC
Great egret	<i>Casmerodius albus</i>	NL	SSC
Loggerhead shrike	<i>Lanius ludovicianus</i>	C2	NL
Merlin	<i>Falco columbarius</i>	NL	SSC
Northern goshawk	<i>Accipiter gentilis</i>	C2	NL
Peregrine falcon ^b	<i>Falco peregrinus</i>	E	E
White-faced ibis	<i>Plegadis chihi</i>	C2	NL
Plants^d			
King's bladderpod	<i>Lesquerella kingii</i> var. <i>cobrensis</i>	NL	M
Large-flowered gymnostris	<i>Gymnostris nudicaulis</i>	NL	M
Lemhi milkvetch	<i>Astragalus aquilonius</i>	NL	SP2
Nipple cactus	<i>Coryphantha missouriensis</i>	NL	M
Tree-like oxytheca	<i>Oxytheca dendroidea</i>	NL	S
Painted milkvetch	<i>Astragalus ceramicus</i> var. <i>apus</i>	NL	M
Plains milkvetch	<i>Astragalus gilviflorus</i>	NL	SP1
Spreading gilia	<i>Gilia polycladon</i>	NL	SP2
Thistle milkvetch	<i>Astragalus kentrophyta</i> var. <i>jessiae</i>	NL	S
Winged-seed evening primrose	<i>Camissonia pterosperma</i>	NL	S

^a Status codes: C2 - candidate Category 2 (possibly appropriate for protection); E - endangered; M - monitor; NL - not listed; S - sensitive; SP1 - State priority 1 (in danger of becoming extinct in the state); SP2 - State priority 2 (likely to be classified as Priority 1 if factors contributing to decline remain unchanged); SSC - state special concern; T - threatened.

^b USFWS Recovery Plan exists for this species.

^c Species known to occur on proposed tritium supply site.

^d State status of plant species is designated by the Idaho Native Plant Society.

Source: 50 CFR 17.11; 50 CFR 17.12; 55 FR 6184; 56 FR 58804; DOE 1992e; DOE 1994e; IN DFG 1992a; IN DOE 1984a.

TABLE C-3.—Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found On the Site or In the Vicinity of Nevada Test Site

Common Name	Scientific Name	Status ^a	
		Federal	State
Mammal			
Spotted bat	<i>Euderma maculatum</i>	C2	NL
Birds			
American peregrine falcon ^{b,c}	<i>Falco peregrinus anatum</i>	E	E
Arctic peregrine falcon ^b	<i>Falco peregrinus tundrius</i>	T	NL
Bald eagle ^c	<i>Haliaeetus leucocephalus</i>	T	T
Ferruginous hawk ^d	<i>Buteo regalis</i>	C2	NL
Loggerhead shrike ^d	<i>Lanius ludovicianus</i>	C2	NL
Mountain plover ^d	<i>Charadrius montanus</i>	C2	NL
Western least bittern	<i>Ixobrychus exilis hesperis</i>	C2	NL
Western snowy plover ^d	<i>Charadrius alexandrinus nivosus</i>	C2	NL
White-faced ibis ^d	<i>Plegadis chihi</i>	C2	NL
Reptiles			
Chuckwalla	<i>Sauromalus obesus</i>	C2	NL
Desert tortoise ^{d,e}	<i>Gopherus agassizii</i>	T	T
Fish			
Devils Hole pupfish ^{c,f}	<i>Cyprinodon diabolis</i>	E	E
Plants			
Amargosa penstemon	<i>Penstemon fruticiformis</i> var. <i>amargosae</i>	C2	NL
Beardtongue ^d	<i>Penstemon pahutensis</i>	C2	NL
Beatley milkvetch ^d	<i>Astragalus beatleyae</i>	C1	CE
Beatley phacelia ^d	<i>Phacelia beatleyae</i>	C2	NL
Black wooly-pod ^d	<i>Astragalus funereus</i>	C2	NL
Camissonia megalantha ^d	<i>Camissonia megalantha</i>	C2	NL
Cymopterus	<i>Cymopterus ripleyi</i> var. <i>saniculoides</i>	C2	NL
Green-gentian ^d	<i>Frasera pahutensis</i>	C2	NL
Kingston bedstraw ^d	<i>Galium hilendiae</i> ssp. <i>kinstonense</i>	C2	NL
Mojave fishhook cactus ^d	<i>Sclerocactus polyancistrus</i>	NL	CY
White bear desert-poppy ^d	<i>Arctomecon merriamii</i>	C2	NL

^a Status codes: C1 - candidate Category 1 (appropriate for protection); C2 - candidate Category 2 (possibly appropriate for protection); CE - critically endangered by authority of NRS 527.270 (State Division of Forestry); CY - protected by authority of NRS 522.60-.120 (Nevada Cacti and Yucca Law); NL - not listed; T - threatened.

^b Peregrine falcon seen on NTS; however not identified to subspecies level.

^c USFWS Recovery Plan exists for this species.

^d Species recorded on NTS.

^e Species known to occur on proposed tritium supply site.

^f Only known location of this species is outside the NTS 24 miles southwest of Mercury. This species is included here due to potential offsite groundwater impacts.

Note: Nevada Department of Wildlife and currently revising the state threatened and endangered species list.

Source: 50 CFR 17.11; 50 CFR 17.12; 55 FR 6184; 56 FR 58804; DOE 1994j; NT FWS 1989a; NT FWS 1991a; NTS 1990a:1; NTS 1990a:2.

TABLE C-4.—Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found On the Site or In the Vicinity of Oak Ridge Reservation [Page 1 of 3]

Common Name	Scientific Name	Status ^a	
		Federal	State
Mammals			
Eastern cougar ^b	<i>Felis concolor cougar</i>	E	E
Eastern woodrat	<i>Neotoma floridana magister</i>	C2	D
Gray bat ^b	<i>Myotis grisescens</i>	E	E
Indiana bat ^b	<i>Myotis sodalis</i>	E	E
River otter	<i>Lutra canadensis</i>	NL	T
Smoky shrew	<i>Sorex fumeus</i>	NL	D
Southeastern shrew	<i>Sorex longirostris</i>	NL	D
Birds			
American peregrine falcon ^b	<i>Falco peregrinus anatum</i>	E	E
Arctic peregrine falcon	<i>Falco peregrinus tundrius</i>	T	E
Bachman's sparrow	<i>Aimophila aestivalis</i>	C2	E
Bald eagle ^b	<i>Haliaeetus leucocephalus</i>	T	T
Barn owl	<i>Tyto alba</i>	NL	D
Bewick's wren	<i>Thyromanes bewickii altus</i>	C2	T
Black-crowned night heron	<i>Nycticorax nycticorax</i>	NL	D
Black vulture ^c	<i>Coragyps atratus</i>	NL	D
Cooper's hawk ^c	<i>Accipiter cooperii</i>	NL	T
Grasshopper sparrow	<i>Ammodramus savannarum</i>	NL	T
Northern harrier	<i>Circus cyaneus</i>	NL	T
Osprey	<i>Pandion haliaetus</i>	NL	E
Red-cockaded woodpecker	<i>Picoides borealis</i>	E	E
Red-shouldered hawk ^c	<i>Buteo lineatus</i>	NL	D
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>	NL	D
Sharp-shinned hawk ^c	<i>Accipiter striatus</i>	NL	T
Reptiles			
Cumberland slider	<i>Chrysemys scripta troosti</i>	NL	D
Eastern slender glass lizard	<i>Ophisaurus attenuatus longicaudus</i>	NL	D
Northern pine snake	<i>Pituophis melanoleucus melanoleucus</i>	C2	T
Six-lined racerunner	<i>Cnemidophorus sexlineatus</i>	NL	D
Amphibians			
Green salamander	<i>Aneides aeneus</i>	NL	D
Hellbender ^c	<i>Cryptobranchus alleganiensis</i>	C2	D
Tennessee cave salamander	<i>Gyrinophilus palleucus</i>	C2	T

TABLE C-4.—Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found On the Site or In the Vicinity of Oak Ridge Reservation [Page 2 of 3]

Common Name	Scientific Name	Status ^a	
		Federal	State
Fishes			
Alabama shad	<i>Alosa alabamiae</i>	NL	D
Amber darter ^b	<i>Percina antesella</i>	E	E
Blue sucker	<i>Cycleptus elongatus</i>	C2	T
Flame chub	<i>Hemitremia flammea</i>	NL	D
Frecklebelly madtom	<i>Noturus munitus</i>	C2	T
Highfin carpsucker	<i>Carpionodes velifer</i>	NL	D
Spotfin chub ^b	<i>Cyprinella monacha</i>	T	E
Tennessee dace ^c	<i>Phoxinus tennesseensis</i>	NL	D
Yellowfin madtom ^b	<i>Noturus flavipinnis</i>	T	E
Invertebrates			
Alabama lamp pearly mussel ^b	<i>Lampsilis virescens</i>	E	E
Appalachian monkeyface pearly mussel ^b	<i>Quadrula sparsa</i>	E	E
Birdwing pearly mussel ^b	<i>Conradilla caelata</i>	E	E
Cumberland bean pearly mussel ^b	<i>Villosa trabalis</i>	E	E
Cumberland monkeyface pearly mussel ^b	<i>Quadrula intermedia</i>	E	E
Dromedary pearly mussel ^b	<i>Dromus dromas</i>	E	E
Fine-rayed pigtoe pearly mussel ^b	<i>Fusconaia cuneolus</i>	E	E
Green-blossom pearly mussel ^b	<i>Epioblasma torulosa gubernaculum</i>	E	E
Orange-footed pearly mussel ^b	<i>Plethobasus cooperianus</i>	E	E
Painted snake coiled forest snail	<i>Anguispira picta</i>	T	E
Pale lilliput pearly mussel ^b	<i>Toxolasma cylindrellus</i>	E	E
Pink mucket pearly mussel ^b	<i>Lampsilis orbiculata orbiculata</i>	E	E
Rough pigtoe pearly mussel ^b	<i>Pleurobema plenum</i>	E	E
Shiny pigtoe pearly mussel ^b	<i>Fusconaia edgariana</i>	E	E
Tan riffle shell pearly mussel ^b	<i>Epioblasma walkeri</i>	E	E
Tubercled-blossom pearly mussel ^b	<i>Epioblasma torulosa torulosa</i>	E	E
Turgid-blossom pearly mussel ^b	<i>Epioblasma turgidula</i>	E	E
White warty back pearly mussel ^b	<i>Plethobasus cicatricosus</i>	E	E
Yellow-blossom pearly mussel ^b	<i>Epioblasma florentina florentina</i>	E	E

TABLE C-4.—Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found On the Site or In the Vicinity of Oak Ridge Reservation [Page 3 of 3]

Common Name	Scientific Name	Status ^a	
		Federal	State
Plants			
American barberry	<i>Berberis canadensis</i>	NL	S
Appalachian bugbane	<i>Cimicifuga rubifolia</i>	C2	T
Branching whitlowgrass	<i>Draba ramosissima</i>	NL	S
Butternut	<i>Juglans cinerea</i>	C2	T
Canada (wild yellow) lily ^c	<i>Lilium canadense</i>	NL	T
Carey's saxifrage	<i>Saxifraga careyana</i>	NL	S
Catfoot	<i>Gnaphalium helleri</i>	NL	S
False-foxglove	<i>Tomanthera auriculata</i>	C2	E
Fen orchid ^c	<i>Liparis loeselii</i>	NL	E
Ginseng ^c	<i>Panax quinquefolius</i>	NL	T
Golden seal ^c	<i>Hydrastis canadensis</i>	NL	T
Gravid sedge ^c	<i>Carex gravida</i>	NL	S
Heartleaf meehania	<i>Meehanian cordata</i>	NL	T
Lesser ladies' tresses	<i>Spiranthes ovalis</i>	NL	S
Michigan lily ^c	<i>Lilium michiganense</i>	NL	T
Mountain honeysuckle	<i>Lonicera dioica</i>	NL	S
Mountain witch alder	<i>Fothergilla major</i>	NL	T
Northern bush honeysuckle	<i>Diervilla lonicera</i>	NL	T
Nuttall waterweed	<i>Elodea nuttallii</i>	NL	S
Pink lady's-slipper ^c	<i>Cypripedium acaule</i>	NL	E
Prairie goldenrod	<i>Solidago ptarmicoides</i>	NL	E
Purple fringeless orchid ^c	<i>Platanthera peramoena</i>	NL	T
Slender blazing star	<i>Liatris cylindracea</i>	NL	E
Spreading false foxglove	<i>Aureolaria patula</i>	C1	T
Swamp lousewort	<i>Pedicularis lanceolata</i>	NL	T
Whorled mountainmint	<i>Pycnanthemum verticallum</i>	NL	E,P
Tall larkspur	<i>Delphinium exaltatum</i>	C2	E
Tennessee purple coneflower ^b	<i>Echinacea tennesseensis</i>	E	E
Tubercled rein-orchid ^c	<i>Platanthera flava</i>	NL	T
Virginia spiraea	<i>Spiraea virginiana</i>	T	E

^a Status codes: C1 - candidate Category 1 (appropriate for protection); C2 - candidate Category 2 (possibly appropriate for protection); D - deemed in need of management; E - endangered; NL - not listed; SSC - State, special concern; T - threatened.

^b USFWS Recovery Plan exists for this species.

^c Species known to occur on or near proposed tritium supply site.

Source: 50 CFR 17.11; 50 CFR 17.12; 55 FR 6184; 56 FR 58804; 56 FR 64229; DOE 1994j; OR DEC 1992a; OR DEC 1992b; OR DEC 1992c; OR DEC 1992d; OR DOE 1990a; OR FWS 1992b; OR NERP 1993a; OR WRC 1991a; OR WRC 1991b; ORNL 1981a; ORNL 1984b; ORNL 1988c.

TABLE C-5.—Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found On the Site or In the Vicinity of Pantex Plant

Common Name	Scientific Name	Status ^a	
		Federal	State
Mammals			
Black-footed ferret ^{b,c}	<i>Mustela nigripes</i>	E	E
Plains spotted skunk	<i>Spilogale putorius interrupta</i>	C2	NL
Swift fox ^d	<i>Vulpes velox</i>	C2	NL
Birds			
American peregrine falcon ^b	<i>Falco peregrinus anatum</i>	E	E
Arctic peregrine falcon	<i>Falco peregrinus tundrius</i>	T	T
Bald eagle ^{b,d}	<i>Haliaeetus leucocephalus</i>	T	T
Baird's sparrow	<i>Ammodramus bairdii</i>	C2	NL
Black tern ^d	<i>Chlidonias niger</i>	C2	NL
Ferruginous hawk ^d	<i>Buteo regalis</i>	C2	NL
Interior least tern ^b	<i>Sterna antillarum athalassos</i>	E	E
Loggerhead shrike ^d	<i>Lanius ludovicianus</i>	C2	NL
Mountain plover	<i>Charadrius montanus</i>	C2	NL
Western snowy plover	<i>Charadrius alexandrinus nivosus</i>	C2	NL
White-faced ibis ^d	<i>Plegadis chihi</i>	C2	T
Whooping crane ^{b,d}	<i>Grus americana</i>	E	E
Reptiles			
Smooth green snake	<i>Ophedorys vernalis</i>	NL	E
Texas garter snake	<i>Thamnophis sirtalis annectans</i>	C2	NL
Texas horned lizard ^d	<i>Phrynosoma cornutum</i>	C2	T

^a Status codes: C1 - candidate Category 1 (appropriate for protection); C2 - candidate Category 2 (possibly appropriate for protection); E - endangered; NL - not listed; T - threatened.

^b USFWS Recovery Plan exists for this species.

^c Believed extirpated from Texas.

^d Species observed on Pantex Plant.

Source: 50 CFR 17.11; 50 CFR 17.12; 55 FR 6184; 56 FR 58804; PX 1994a:1; PX DOE 1994b; PX MH 1994c; PX PWD 1991b; PX PWD 1993a; PX PWD 1993b; PX WTS 1992a.

TABLE C-6.—Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found On the Site or In the Vicinity of Savannah River Site [Page 1 of 2]

Common Name	Scientific Name	Status ^a	
		Federal	State
Mammals			
Southern Appalachian eastern woodrat	<i>Neotoma floridana haematoreia</i>	C2	UN
Rafinesque's big-eared bat	<i>Plecotus rafinesquii</i>	C2	SE
Star-nosed mole	<i>Condylura cristata parva</i>	NL	UN
Swamp rabbit	<i>Sylvilagus aquaticus</i>	NL	UN
Birds			
American peregrine falcon ^b	<i>Falco peregrinus anatum</i>	E	SE
Arctic peregrine falcon	<i>Falco peregrinus tundrius</i>	T	ST
Bachman's sparrow	<i>Aimophila aestivalis</i>	C2	NL
Bald eagle ^b	<i>Haliaeetus leucocephalus</i>	T	T
Bewick's wren	<i>Thyromanes bewickii altus</i>	C2	ST
Cooper's hawk ^c	<i>Accipiter cooperii</i>	NL	UN
Loggerhead shrike	<i>Lanius ludovicianus</i>	C2	NL
Mississippi kite	<i>Ictinia mississippiensis</i>	NL	UN
Osprey	<i>Pandion haliaetus</i>	NL	SC
Red-cockaded woodpecker ^b	<i>Picoides borealis</i>	E	SE
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>	NL	SC
Wood stork ^{b,d}	<i>Mycteria americana</i>	E	SE
Reptiles			
American alligator	<i>Alligator mississippiensis</i>	T	NL
Carolina swamp snake	<i>Seminatrix pygaea</i>	NL	UN
Eastern coral snake	<i>Micrurus fulvius fulvius</i>	NL	UN
Northern pine snake	<i>Pituophis melanoleucus melanoleucus</i>	C2	NL
Southern hognose snake	<i>Heterodon simus</i>	C2	NL
Spotted turtle	<i>Clemmys guttata</i>	NL	UN
Amphibians			
Carolina crawfish frog	<i>Rana areolata capito</i>	C2	SC
Eastern bird-voiced treefrog	<i>Hyla avivoca ogechiensis</i>	NL	UN
Eastern tiger salamander ^d	<i>Ambystoma tigrinum tigrinum</i>	NL	SC
Pickerel frog ^d	<i>Rana palustris</i>	NL	UN
Upland chorus frog	<i>Pseudacris triseriata feriarum</i>	NL	SC
Fishes			
Bighead (Savannah) redhorse	<i>Moxostoma sp.</i>	C2	NL
Shortnose sturgeon ^{b,d}	<i>Acipenser brevirostrum</i>	E	SE
Invertebrates			
American sandburrowing mayfly	<i>Dolania americana</i>	C2	NL
Brother spike mussel	<i>Elliptio fraterna</i>	NL	SE

TABLE C-6.—Federal- and State-Listed Threatened, Endangered, and Other Special Status Species That May Be Found On the Site or In the Vicinity of Savannah River Site [Page 2 of 2]

Common Name	Scientific Name	Status ^a	
		Federal	State
Plants			
Awned meadow-beauty ^c	<i>Rhexia aristosa</i>	C2	NL
Beak-rush ^d	<i>Rhynchospora inundata</i>	NL	UN
Beak-rush ^d	<i>Rhynchospora tracyi</i>	NL	UN
Bog spice bush	<i>Lindera subcoriacea</i>	C2	RC
Cypress stump sedge ^d	<i>Carex decomposita</i>	NL	UN
Dwarf bladderwort	<i>Utricularia olivacea</i>	NL	SL
Elliott's croton	<i>Croton elliotii</i>	NL	UN
Few-fruited sedge	<i>Carex oligocarpa</i>	NL	UN
Florida bladderwort	<i>Utricularia floridana</i>	NL	SL
Florida false loosestrife ^c	<i>Ludwigia spathulata</i>	NL	UN
Gaura	<i>Gaura biennis</i>	NL	UN
Green-fringed orchid ^c	<i>Platanthera lacera</i>	NL	SL
Leafy pondweed	<i>Potamogeton foliosus</i>	NL	UN
Little bur-head	<i>Echinodorus tenellus</i>	NL	SL
Loose water-milfoil	<i>Myriophyllum laxum</i>	C2	RC
Milk-pea	<i>Astragalus villosus</i>	NL	UN
Nailwort	<i>Paronychia americana</i>	NL	UN
Nestronia	<i>Nestronia umbellula</i>	C2	NL
Nutmeg hickory	<i>Carya myristiciformis</i>	NL	RC
Oconee azalea	<i>Rhododendron flammeum</i>	NL	SL
Pink tickseed	<i>Coreopsis rosea</i>	NL	RC
Quill-leaved swamp potato	<i>Sagittaria isoetiformis</i>	NL	SL
Sandhill lily	<i>Nolina georgiana</i>	NL	UN
Smooth purple coneflower	<i>Echinacea laevigata</i>	E	NC
Swamp lobelia	<i>Lobelia boykinii</i>	C2	NL
Trepocarpus	<i>Trepocarpus aethusae</i>	NL	UN
Wild water-celery	<i>Vallisneria americana</i>	NL	UN
Yellow cress	<i>Rorippa sessiliflora</i>	NL	UN
Yellow porilla	<i>Menispermum canadense</i>	NL	UN
Yellow wild indigo	<i>Baptisia lanceolata</i>	NL	UN

^a Status codes: C2 - candidate Category 2 (possibly appropriate for protection); E - endangered; NC - national, of concern, (plant); NL - not listed; PE - proposed endangered; RC - region, of concern, (plants); SC - state, of concern, (animals); SE - state, endangered (animals); SL - state, of concern, (plants); ST - state, threatened (animals); T - threatened; UN - undetermined.

^b USFWS Recovery Plan exists for this species.

^c Species known to occur near Rainbow bay adjacent to proposed tritium supply site.

^d Species occurs in discharge receiving areas.

Source: 50 CFR 17.11; 50 CFR 17.12; 55 FR 6184; 56 FR 58804; 56 FR 64229; DOE 1994g; SR NERP 1990b; SR WMRD 1991a; SR WMRD 1991b; SR WMRD 1992a; SR WMRD 1992b; WSRC 1989e.

APPENDIX D

Appendix D

Appendix D

APPENDIX D: SOCIOECONOMICS

D.1 INTRODUCTION

This appendix includes the methodologies, models, assumptions, and supporting data used for assessing potential impacts in the socioeconomics sections of this Programmatic Environmental Impact Statement (PEIS). Section D.2 presents the methods and assumptions used to evaluate the potential socioeconomic effects of the proposed siting of tritium supply technologies and recycling facilities. The socioeconomic analysis involved two major steps: (1) the characterization and projection of existing social, economic, and infrastructure conditions surrounding each of the candidate sites (i.e., the affected environment); and (2) the evaluation of potential changes in socioeconomic conditions that could result from the construction and operation of tritium supply technologies and recycling facilities in the regions addressed (i.e., the environmental consequences). In addition, potential changes in socioeconomic conditions that could result from the construction and operation of a multipurpose reactor and a gas-fired power plant to support the Accelerator Production of Tritium (APT) are also analyzed. Supporting data for the affected environment and environmental consequences sections are presented in tables contained entirely at the end of the text in section D.3.

D.2 METHODOLOGIES AND MODELS

D.2.1 Employment and Population

The description of socioeconomic conditions includes indicators, such as population, civilian labor

force, employment, unemployment rate, and income, that provide a basis for comparing regional socioeconomic conditions among the sites with No Action and with the various alternatives. The No Action alternative was considered equivalent to future baseline conditions without new activities. The baseline for the No Action alternative was established from the total employment projected for each of the sites at the end of fiscal year 1994. These proposed fiscal year 1994 budget and employment estimates were provided by each site and are believed to best reflect the staffing levels needed as a result of recent stockpile requirement reductions. Table D.2.1-1 presents historical employment and future employment projections for each site.

Region of Influence and Regional Economic Area.

For each site, socioeconomic impacts were estimated using two geographic areas. First, a region of influence (ROI) was identified based on the distribution of residences for current Department of Energy (DOE) and contractor personnel working at each of the proposed sites. The ROIs were determined to be those areas in which approximately 90 percent of the current DOE and contractor employees reside, and counties in which at least 5 percent of the DOE workforce lives. This residential distribution reflects existing commuting patterns and attractiveness of area communities for people employed at each site, and was used to estimate the future distribution of direct workers associated with the proposed alternatives.

TABLE D.2.1-1.—*Historical and Projected Site Employment*

Site	1970	1990	1992	1994	2005	2010
INEL	6,755	11,100	11,600	10,100	10,100	10,100
NTS	6,840	8,019	7,696	6,850	6,850	6,850
ORR	14,257	15,273	16,238	15,000	15,000	15,000
Pantex Plant	1,630	2,394	2,681	3,400	1,790	1,790
SRS	5,737	22,290	21,823	20,300	16,900	16,900

Source: DOE 1994e; INEL 1991a:6; NTS 1990a:3; NTS 1991a:1; NTS 1992a:7; NTS 1994a:1; ORR 1991a:4; ORR 1993a:8; ORR 1994a:1; PX 1991a:5; PX 1993a:2; PX MH 1994a; PX MH 1994b; PX MH 1994c; SRS 1992a:9; SRS 1993a:3; SRS 1994a:3.

As an example, table D.3-1 displays the residential distribution by city and county for all personnel employed at the Idaho National Engineering Laboratory (INEL). Data on residential location for a large portion of facility employees were obtained from INEL personnel offices. Similar data were provided by the other locations and are given in tables D.3-21, D.3-37, D.3-52, and D.3-72.

A second geographical area, referred to as a regional economic area, was also identified for estimating socioeconomic impacts. The regional economic area is a 50-mile radius around each site that encompasses a broad market that involves trade among and between regional industrial and service sectors and which is characterized by strong economic linkages between the communities located in the region. These linkages determine the nature and magnitude of multiplier effects of economic activity at each candidate site. The regional economic area is used to analyze the primary economic impacts on employment, spending, earnings, and personal income. Table D.2.1-2 displays the counties found in each site's regional economic area. As an example, later in this appendix table D.3-2 displays the employment, civilian labor force, unemployment rate, and personal and per capita incomes for the INEL regional economic area. Similar data were provided by other locations and are given in tables D.3-22, D.3-38, D.3-53, and D.3-73. Impacts on employment from alternatives compared to No Action

during construction and operation are given in tables D.3-3, D.3-4, D.3-23, D.3-24, D.3-39, D.3-40, D.3-54, D.3-55, and D.3-74.

Existing and Future Baseline. Historical and existing population, labor force, employment, and income data were obtained from the U.S. Bureau of Economic Analysis Regional Economic Information Systems. Historical personal income and per capita income values were converted to constant 1992 dollars using the current Department of Commerce National Income Deflator Index. Employment by place of work was converted to employment by place of residence on the basis of ratios derived from Bureau of Census, Bureau of Labor Statistics, and Bureau of Economic Analysis data.

Growth projections for population, labor force, employment, and income were based on Bureau of Economic Analysis Regional Projections to 2040 for Bureau of Economic Analysis economic regions and metropolitan statistical areas. Bureau of Economic Analysis projections are for multi-county economic regions or whole metropolitan statistical areas; therefore, projections for individual counties were made by applying the appropriate growth rates for each Bureau of Economic Analysis data series (population, employment, etc.) to each county in the identified ROI for each site. Data series forecasts for counties within a metropolitan statistical area were based on the higher Bureau of Economic Analysis

TABLE D.2.1-2.—Counties Representing the Candidate Sites' Regional Economic Areas

INEL	NTS	ORR	Pantex Plant	SRS		
Idaho	California	Kentucky	Tennessee	Texas	Georgia	South
Bannock	Inyo	Bell	(continued)	Armstrong	Bulloch	Carolina
Bingham		McCreary	Grainger	Bricoe	Burke	Aiken
Blaine	Nevada	Wayne	Hamblen	Carson	Columbia	Allendale
Bonneville	Clark	Whitley	Jefferson	Castro	Effingham	Bamberg
Butte	Lincoln		Knox	Deaf Smith	Emanuel	Barnwell
Clark	Nye	North Carolina	Loudon	Donley	Glascok	Calhoun
Custer		Graham	McMinn	Gray	Jefferson	Colleton
Fremont		Swain	Meigs	Harley	Jenkins	Edgefield
Jefferson		Tennessee	Monroe	Hutchinson	Lincoln	Greenwood
Lemhi		Anderson	Morgan	Moore	McDuffie	Hampton
Madison		Bledsoe	Overton	Oldham	Richmond	Jasper
Minidoka		Blount	Putnam	Potter	Screven	Lexington
Power		Campbell	Rhea	Randall	Warren	Orangeburg
		Claiborne	Roane	Roberts		Saluda
		Cumberland	Scott	Swisher		
		Fentress	Sevier			
			Union			

Source: McNalley 1985a; USGS 1972a.

growth rates projected for metropolitan areas, while forecasts for other counties in the ROI were based on generally lower regional growth projections.

Potential Project Effects. Total output multipliers for each region were obtained from the U.S. Department of Commerce, Bureau of Economic Analysis Regional Inter-industry Multiplier System, and utilized in an economic model developed for evaluation of socioeconomic impacts of large-scale government programs.

The model includes four major components for the analysis:

- Regional inter-industry component that produced a regional input/output table and output multipliers for each specified sector of the economy for each regional economic area.
- Direct effects component that produced a matrix of final demands (estimated changes in industry and household spending due to project activities) on the basis of direct employment and procurement associated with the project.
- Employment impact component that calculated region-wide indirect output, earnings, and employment estimates.
- Macroeconomic impact component that calculated regional population impacts on the basis of assumptions concerning possible changes in unemployment, the share of the labor force with the necessary skills to take direct project jobs, and the portion of the direct employment that would in-migrate to the ROI.

These inter-industry multipliers were estimated using the Bureau's input/output table for the United States in combination with the most recent region-specific information describing the relationship of the regional economy to the national economy.

The same methodology was used to develop quantitative projections of economic activity for No Action conditions and the alternatives. Project-related

changes in regional demand in each local industrial and household sector were first estimated as follows:

- Construction-phase demands were based on construction labor and cost data provided by Fluor-Daniel, Inc., engineers, and the DOE sites affected by the proposal from parameters developed in support of the description of alternatives development.
- Operation-phase demands were estimated from data provided by Fluor-Daniel, Inc. and DOE operations employment estimates and procurement requirements from existing DOE facilities that provide similar manufacturing activities.

The direct effects component uses the construction and operations demand to determine the procurement in the specific industries and the personal consumption expenditures (household spending) due to the project activities, taking into consideration the disposable income of each type of direct employment category.

These primary or direct effects were then multiplied, using Regional Inter-industry Multiplier System coefficients specific to the regional economy, to provide estimated total spending associated with the alternatives. Input-output sectors were selected to reflect the anticipated spending profile associated with the alternatives in order to capture the economic characteristics of each scenario within the regional economic area. The employment impact component thus estimates the indirect employment, earnings, and personal income due to the alternatives. Table D.2.1-3 presents the assumptions for direct and indirect employment that were used for the regional socioeconomic analysis.

The macroeconomic impact component uses the information regarding the direct and indirect employment from the direct effects and employment impact components, as well as the baseline information, to estimate the direct and indirect employment that would in-migrate into the ROI. Numbers of in-migrant workers associated with each alternative were estimated according to a set of assumptions concerning the availability of required labor skill levels within each regional labor force and the recog-

TABLE D.2.1-3.—Assumptions for Regional Economic Area

Employment	Category			
	PRDEP	HHS	FF	NLOC
Direct				
Construction				
Direct	0.238 ^a	3.11 ^b	0.589 ^b	0.25
Support	0.238 ^a	2.93 ^b	0.618 ^b	0.75
Operation				
DOE operations	0.247 ^a	3.17 ^c	0.708 ^c	0.50
Indirect				
Personal consumption		3.17 ^c	0.708 ^c	
Procurement		3.17 ^c	0.708 ^c	
Related investment		3.17 ^c	0.708 ^c	

^a CEA 1992a; OWRC 1975a.

^b USCOE 1981a.

^c DOC 1991a.

Note: PRDEP - Labor force participation rate of the dependents of in-migrating workforce; HHS - Household size of workers accompanied by dependents; FF - Fraction of workers accompanied by dependents; NLOC - Proportion of workers assumed to be nonlocal.

dition that competitive bidding for both construction and operations activities would bring in a certain number of workers regardless of available labor. For smaller demands of construction and operations activities as compared to regional labor availability, in-migrant workers were primarily associated with contract award relocation assumptions. In addition to analyzing the population changes due to in-migrant workers, population changes due to out-migrations of workers from sites that would have workforce reductions as a result of the phasing out missions were examined. These population projections are conservative because they are estimated under the assumption that all the jobs lost will occur in the single year 2010.

Average household sizes for in-migrant workers were assumed to correspond, for most categories, with the average size of state-to-state migrating families between 1980 and 1990. The intra-regional allocation analysis accounts for the distribution of direct and indirect workers and their families among the various residential areas within each region. The direct effect portion of the allocation process accounts for the two main factors affecting the distribution of in-migrant direct workers: (1) the number of workers anticipated to be directly involved with each alternative and (2) the locations and relative attractiveness of residential opportunities within the region. Analytic methods are basically similar for

assessing both population increases due to immigration of direct and indirect workers and their families and population decreases due to out-migration of direct and indirect workers and their families.

Population changes associated with the alternatives are an important determinant of other socioeconomic and environmental impacts. These population changes have three key components: (1) baseline growth; (2) relocation of workers and their dependents; and (3) natural increase of population (births minus deaths) over the long term. To evaluate anticipated population effects, potential future changes associated with the tritium supply technologies and recycling facilities were compared to projected baseline conditions.

The computer output of the macroeconomic impact component for INEL is presented in table D.2.1-4. The first page of the table presents the employment and population parameter values used for this analysis and baseline and project information. The second page presents direct and indirect project impacts and a summary of effects for the year 2001. Similar output was created for all project years through 2010. Table D.3-2 is a summary of the employment and local economy results for INEL for selected years between 1970 and 2020. Population and economic data for all the sites are given in tables

TABLE D.2.1-4.—Parameters Used by the Model Idaho National Engineering Laboratory
Example [Page 1 of 2]

Parameters Used By the Model

MSLF = .1000 FUR = .0428

Direct Employment Parameters

Category	DSHARE	DUR	PRDEP	DURDEP	HHS	FF	DCIV	NLNTR	NLRLOC	SHWCOM
Construction-direct	.082	.043	.238	.043	3.110	.589	1.000	.000	.250	.000
Construction-support	.014	.043	.238	.043	2.930	.618	1.000	.000	.750	.000
DOE operations	.089	.043	.247	.043	3.170	.708	1.000	.000	.500	.000

Indirect Employment Parameters

Category	IUR	HHS	FF
Personal consumption	.043	3.170	.708
Procurement	.043	3.170	.708
Related investment	.043	3.170	.708

Logistic Labor Force Response Parameters

Proportion of population that is of working age = 0.643

Beta parameter of effect of project jobs on labor force participation (0 = no effect) = 0.0000

Year: 2001

Baseline Information

Population	286,010
Civilian labor force	140,059
Labor force participation rate (w/o project.)	.4897
Employed civilian labor force (w/o project.)	131,039
Unemployment rate	.064
Total employment (w/o project.)	131,043
Earnings (\$1,000)	3,351,102
Personal income (\$1,000)	4,703,569
Per capita income (w/o project.)	16,445

Project Information

Employment Category	Direct Employment	Earnings (\$1,000)	Personal Income (\$1,000)
Construction-direct	297.0	6,821	6,821
Construction-support	45.0	2,115	2,115
DOE operations	0.0	0.0	0.0
Subtotal	342.0	8,937	8,937

Indirect Employment

Personal consumption	108.3	3,115	4,372
Procurement	516.2	18,864	26,477
Related investment	0.0	0.0	0.0
Subtotal	624.5	21,979	30,849
Total-place of work	966.5	30,915	39,786
Weekly commuting adjustment			0.0
Total-place of residence			39,786

Direct and Indirect Project Impacts

Direct Employment Category

Category	Available Residential	Labor		Population		Accompanying	
	Labor Force	Excess Demand	Force Increase	Dependents	Impacts	Weekly Commuters	Labor Force
Construction-direct	248.07	74.25	77.57	96.40	173.97	.00	22.94
Construction-support	42.35	33.75	35.26	42.05	77.31	.00	10.01
DOE operations	269.25	.00	.00	.00	.00	.00	.00
Subtotal	559.68	108.00	112.83	138.46	251.29	.00	32.95

TABLE D.2.1-4.—Parameters Used by the Model Idaho National Engineering Laboratory
Example [Page 2 of 2]

Indirect Employment Category						
Category	Demand Share of Available Residential Labor Force	Excess Demand	Labor Force Increase	Dependents	Population Impacts	Labor Force Share
Personal consumption	427.57	.00	.00	.00	.00	.14
Procurement	2,038.03	.00	.00	.00	.00	.67
Related investment	.00	.00	.00	.00	.00	.00
Subtotal	2,465.60	.00	.00	.00	.00	.81
Total	3,025.28	108.00	112.83	138.46	251.29	33.76

Summary of Effects	
Employment:	
Direct employment (all categories)	342
Indirect employment (all categories)	624
Total project-related employment	966
Project-related civilian employment	966
Civilian labor force increase	146
Civilian labor force (w/project)	140,205
Employed civilian labor force (w/project)	132,006
Unemployment rate (w/project)	.058
Total employment (w/project)	132,009
Adjusted baseline labor force participation rate (w/project)	.4897
Labor force partic. rate (w/project)	.4898
Maximum employment of accompanying labor force	32
Population:	
Total population impact	251
Total population (w/project)	286,261
Direct weekly commuters	0.00
Income:	
Direct project-related earnings (\$1,000)	8,937
Direct project-related resident earnings (\$1,000)	8,937
Indirect project-related earnings (\$1,000)	21,979
Earnings (w/project \$1,000)	3,382,017
Personal income impact of project (\$1,000)	39,786
Personal income (w/project \$1,000)	4,743,355
Per capita income (w/project)	16,570

Abbreviations

- DCIV - Fraction of direct employment which can be filled by civilians.
- DSHARE - Employable share of available resident labor force.
- DUR - Unemployment rate, in-migrant workers (Direct employment).
- DURDEP - Unemployment rate, dependents of in-migrant workers.
- FF - Fraction of workers accompanied by dependents.
- FUR - Floor value for minimum unemployment rate.
- HHS - Household size, workers accompanied by dependents.
- IUR - Unemployment rate, in-migrant workers (indirect employment).
- MSLF - Maximum share of baseline labor force employed with project - but unemployed without it.
- NLNOTR - Share of employment assumed to be non-local, and not relocating from out of region.
- NLRLOC - Share of employment assumed to be non-local, but relocating from out of region.
- PRDEP - Labor force participation rate, dependents of in-migrant workers.
- SHWCOM - Share of direct workers who are weekly commuters.

Source: CEA 1992a; Census 1972a; Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOC 1993a; OWRC 1975a; USCOE 1981a; IN Census 1991a; IN DOC 1991a.

D.3-5, D.3-25, D.3-41, D.3-56, and D.3-75. Impacts on population from the alternatives compared to No Action during construction and operation are given in tables D.3-6, D.3-7, D.3-26, D.3-27, D.3-42, D.3-43, D.3-57, D.3-58, and D.3-76.

D.2.2 Housing

Baseline housing characteristics are presented in tables D.3-8, D.3-28, D.3-44, D.3-59, and D.3-77. Projected housing needs are based upon housing unit and population data obtained from the *1990 Census of Population and Housing* for each ROI. Future housing units needed for cities and counties in each ROI were developed by estimating the household size from the current population and housing unit ratios. The household size-to-population ratios were then applied to the estimated future population trends to obtain the number of housing units needed to accommodate the projected population for a No Action alternative future baseline.

Projected housing needs for the alternatives were developed in the same manner as the estimates for a No Action baseline. These estimates, however, include projected in-migrating workforces (and their families) from outside the ROI. Future housing needs for the in-migrating populations, resulting from employment created directly or indirectly by the project, were estimated from the national average household size from the *1990 Census of Population and Housing* for each ROI. Conversely, estimates of additional housing unit vacancies created directly and indirectly by a project alternative as a result of out-migrations were developed from current population and household size ratios. Impacts on housing from the alternatives compared to No Action during construction and operation are given in tables D.3-9, D.3-10, D.3-29, D.3-30, D.3-45, D.3-46, D.3-60, D.3-61, and D.3-78.

D.2.3 Public Finance

Finances of ROI local jurisdictions were evaluated based on changes in historic revenue and expenditure

levels, changes in fund balances, and reserve bonding capabilities. These historic fiscal characteristics were obtained from financial audits and budgets supplied by each jurisdiction. The analysis concentrated on each jurisdiction's governmental funds (general funds, special revenue funds, and, as applicable, capital projects, debt service, and expendable trust funds). Other funds, such as enterprise funds, which are funded principally through user charges without contributing to the general tax burden of area residents, were not included in the analyses.

The analysis of local jurisdictions' public finances focused upon revenues and expenditures because no assumptions could be made for some projected fund balances (such as capital expenditures) so far into the future.

The following parameters were used to project changes in total revenues and expenditures: gains (or losses) of jobs in the region; population increases (or decreases) in each jurisdiction, including school districts; earnings and income gains (or losses); and potential changes in each jurisdiction's property tax base. Public finance characteristics are presented in tables D.3-11, D.3-12, D.3-31, D.3-32, D.3-47, D.3-62, D.3-63, D.3-79, and D.3-80. Impacts on public finance from the alternatives compared to No Action during construction and operation are given in tables D.3-13 through D.3-20A, D.3-33 through D.3-36A, D.3-48 through D.3-51A, D.3-64 through D.3-71A, and D.3-81 through D.3-84A.

D.2.4 Local Transportation

Local transportation impacts are qualitatively assessed in terms of the changes to roadway traffic volumes and service levels associated with tritium supply technologies and recycling activities employment and area population changes.

D.3 SUPPORTING DATA

Data and analyses used to support the assessments made for the socioeconomics section are presented in the following tables.

TABLE D.3-1.—Distribution of Employees by Place of Residence for Idaho National Engineering Laboratory, 1991

County/City	Number of Employees	Total Site Employment (percent)
Bannock County	342	5.3
Pocatello	317	4.9
Bingham County	576	8.9
Blackfoot	460	7.1
Bonneville County	4,893	75.7
Idaho Falls	4,750	73.5
Butte County	123	1.9
Jefferson County	419	6.5
Rigby	320	4.9
Total ROI (County)	6,353	98.3

Note: Data on Westinghouse Electric Company employees were not available and is not included. Butte County was included in the ROI because more than one half of INEL is located within the county.

Source: INEL 1991a:6.

TABLE D.3-2.—Employment and Local Economy Statistics for Idaho National Engineering Laboratory Regional Economic Area, 1970-2020

Regional Economic Area	1970	1980	1990	2005	2010	2020
Civilian labor force	84,030	118,852	128,517	151,249	154,226	150,521
Total employment	79,028	110,805	120,242	141,510	144,295	140,829
Unemployment rate (percent)	6.0	6.8	6.4	6.4	6.4	6.4
Personal income (thousand dollars)	682,703	2,176,049	4,175,612	5,458,323	5,850,853	6,488,596
Per capita income (dollars per person)	3,309	8,214	14,824	18,569	19,565	20,903

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; IN DOC 1991a.

TABLE D.3-3.—Changes to Total Employment, Unemployment Rate, and Per Capita Income During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Tritium Supply Technologies for Idaho National Engineering Laboratory Regional Economic Area

Regional Economic Area	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Total employment	141,510	148,066	4.63	147,755	4.41	151,400	6.99	149,309	5.51	144,900	3.20
Unemployment rate (percent)	6.4	4.5	NA	4.5	NA	4.5	NA	4.5	NA	4.2	NA
Per capita income (dollars per person)	18,569	18,923	1.91	18,929	1.94	18,860	1.57	18,899	1.78	18,615	2.36
Operation											
Total employment	144,295	146,787	1.73	146,733	1.69	146,519	1.54	145,967	1.16	145,967	1.16
Unemployment rate (percent)	6.4	5.4	NA	5.4	NA	5.5	NA	5.6	NA	5.6	NA
Per capita income (dollars per person)	19,565	19,804	1.22	19,800	1.20	19,784	1.12	19,742	0.91	19,742	0.91

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; Census 1990a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN DOC 1991a.

TABLE D.3-3A.—Changes to Total Employment, Unemployment Rate, and Per Capita Income During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Regional Economic Area

Regional Economic Area	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Total employment	141,510	150,157	6.11	154,353	9.08
Unemployment rate (percent)	6.4	4.3	NA	4.5	NA
Per capita income (dollars per person)	18,569	18,934	1.97	18,806	1.28
Operation					
Total employment	144,295	146,168	1.3	149,774	3.8
Unemployment rate (percent)	6.4	5.6	NA	5.5	NA
Per capita income (dollars per person)	19,565	19,764	1.02	19,993	2.19

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN DOC 1991a.

TABLE D.3-4.—Changes to Total Employment, Unemployment Rate, and Per Capita Income During Peak Construction (2005 for Phased APT) and Full Operation (2010) from Tritium Supply Technologies and Recycling for Idaho National Engineering Laboratory Regional Economic Area

Regional Economic Area	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Total employment	141,510	149,012	5.3	148,701	5.08	152,346	7.66	150,256	6.18	145,847	3.87
Unemployment rate (percent)	6.4	4.5	NA	4.5	NA	4.5	NA	4.5	NA	4	NA
Per capita income (dollars per person)	18,569	18,905	1.81	18,911	1.84	18,842	1.47	18,881	1.68	18,669	2.66
Operation											
Total employment	144,295	149,225	3.42	149,172	3.38	148,957	3.23	148,405	2.85	148,405	2.85
Unemployment rate (percent)	6.4	4.6	NA	4.6	NA	4.7	NA	4.9	NA	4.9	NA
Per capita income (dollars per person)	19,565	19,984	2.14	19,980	2.12	19,964	2.04	19,924	1.84	19,924	1.84

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995a; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN DOC 1991a.

TABLE D.3-4A.—Changes to Total Employment, Unemployment Rate, and Per Capita Income During Peak Construction (2005 for Phased APT) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Regional Economic Area

Regional Economic Area	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Total employment	141,510	151,104	6.78	155,299	9.74
Unemployment rate (percent)	6.4	4.3	NA	4.5	NA
Per capita income (dollars per person)	18,569	18,910	1.84	18,789	1.18
Operation					
Total employment	144,295	148,606	2.99	152,213	5.49
Unemployment rate (percent)	6.4	4.8	NA	5	NA
Per capita income (dollars per person)	19,565	19,941	1.92	19,795	1.18

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995a; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN DOC 1991a.

TABLE D.3-5.—Population for Idaho National Engineering Laboratory Region of Influence, 1970-2020

Jurisdiction	1970	1980	1990	2005	2010	2020
Bannock County	52,200	65,421	66,026	69,515	70,721	73,409
Pocatello	40,036	43,340	46,080	48,515	49,357	51,232
Bingham County	29,167	36,489	37,583	39,449	40,133	41,658
Blackfoot	8,716	10,065	9,646	10,125	10,301	10,692
Bonneville County	52,457	65,980	72,207	74,420	75,711	78,588
Idaho Falls	35,776	39,590	43,929	45,275	46,061	47,811
Butte County	2,925	3,342	2,918	3,199	3,254	3,378
Jefferson County	11,740	15,304	16,543	17,166	17,463	18,127
Rigby	2,324	2,624	2,681	2,782	2,830	2,938
Total ROI	148,489	186,536	195,277	203,749	207,282	215,159

Source: Census 1973a; Census 1977a; Census 1983a; IN Census 1991a.

TABLE D.3-6.—Changes to Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies for Idaho National Engineering Laboratory Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Bannock County	69,515	69,908	0.57	69,870	0.51	70,315	1.15	70,060	0.78	69,378	0.49
Pocatello	48,515	48,879	0.75	48,844	0.68	49,255	1.53	49,019	1.04	48,430	0.51
Bingham County	39,449	40,109	1.67	40,045	1.51	40,792	3.4	40,364	2.32	39,426	0.63
Blackfoot	10,125	10,652	5.2	10,601	4.7	11,197	10.59	10,855	7.21	10,164	1.08
Bonneville County	74,420	80,036	7.55	79,494	6.82	85,845	15.35	82,202	10.46	74,935	1.39
Idaho Falls	45,275	50,728	12.04	50,202	10.88	56,369	24.5	52,831	16.69	45,849	1.97
Butte County	3,199	3,339	4.38	3,326	3.97	3,485	8.94	3,394	6.11	3,208	1
Jefferson County	17,166	17,648	2.81	17,601	2.53	18,147	5.71	17,834	3.89	17,180	0.78
Rigby	2,782	3,145	13.05	3,110	11.79	3,521	26.56	3,286	18.12	2,821	2.1
Total ROI	203,749	211,040	3.58	210,336	3.23	218,584	7.28	213,854	4.96	204,127	0.88
Operation											
Bannock County	70,721	70,812	0.13	70,809	0.12	70,797	0.11	70,768	0.07	70,768	0.07
Pocatello	49,357	49,441	0.17	49,438	0.16	49,427	0.14	49,400	0.09	49,400	0.09
Bingham County	40,133	40,285	0.38	40,280	0.37	40,261	0.32	40,212	0.2	40,212	0.2
Blackfoot	10,301	10,422	1.18	10,418	1.14	10,403	0.99	10,364	0.62	10,364	0.62
Bonneville County	75,711	77,004	1.71	76,963	1.65	76,800	1.44	76,379	0.88	76,379	0.88
Idaho Falls	46,061	47,316	2.73	47,277	2.64	47,118	2.3	46,710	1.41	46,710	1.41
Butte County	3,254	3,286	0.98	3,285	0.95	3,281	0.83	3,271	0.52	3,271	0.52
Jefferson County	17,463	17,574	0.63	17,571	0.62	17,556	0.53	17,520	0.32	17,520	0.32
Rigby	2,830	2,914	2.96	2,911	2.86	2,900	2.47	2,873	1.51	2,873	1.51
Total ROI Operation	207,282	208,961	0.81	208,908	0.78	208,695	0.68	208,150	0.42	208,150	0.42

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN Census 1991a.

TABLE D.3-6A.—Changes to Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence

Region of Influence	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Bannock County	69,515	70,313	1.15	70,675	1.67
Pocatello	48,515	48,690	0.36	49,588	2.21
Bingham County	39,449	40,510	2.69	41,397	4.94
Blackfoot	10,125	10,894	7.6	11,679	15.35
Bonneville County	74,420	82,499	10.86	90,991	22.27
Idaho Falls	45,275	53,022	17.11	61,365	35.54
Butte County	3,199	3,406	6.49	3,614	12.99
Jefferson County	17,166	17,898	4.27	18,588	8.29
Rigby	2,782	3,298	18.55	3,855	38.57
Total ROI Construction	203,749	214,626	5.34	225,265	10.56
Operation					
Bannock County	70,721	71,024	0.43	70,995	0.39
Pocatello	49,357	49,535	0.36	49,610	0.51
Bingham County	40,133	40,357	0.56	40,593	1.15
Blackfoot	10,301	10,400	0.97	10,667	3.56
Bonneville County	75,711	76,655	1.25	79,618	5.16
Idaho Falls	46,061	46,879	1.78	49,854	8.24
Butte County	3,254	3,283	0.89	3,352	3.01
Jefferson County	17,463	17,584	0.69	17,799	1.92
Rigby	2,830	2,883	1.87	3,083	8.93
Total ROI Operation	207,282	208,903	0.78	212,357	2.45

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN Census 1991a.

TABLE D.3-7.—Changes to Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies and Recycling for Idaho National Engineering Laboratory Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Bannock County	69,515	70,024	0.73	69,986	0.68	70,431	1.32	70,175	0.95	69,480	0.64
Pocatello	48,515	48,986	0.97	48,950	0.9	49,362	1.75	49,126	1.26	48,512	0.68
Bingham County	39,449	40,303	2.16	40,239	2	40,986	3.9	40,558	2.81	39,531	0.9
Blackfoot	10,125	10,806	6.73	10,756	6.23	11,351	12.11	11,010	8.74	10,229	1.73
Bonneville County	74,420	81,685	9.76	81,142	9.03	87,495	17.57	83,852	12.67	75,588	2.27
Idaho Falls	45,275	52,329	15.58	51,803	14.42	57,971	28.04	54,433	20.23	46,459	3.32
Butte County	3,199	3,381	5.69	3,367	5.25	3,527	10.25	3,435	7.39	3,225	1.52
Jefferson County	17,166	17,789	3.63	17,743	3.36	18,288	6.54	17,975	4.72	17,246	1.16
Rigby	2,782	3,252	16.89	3,217	15.64	3,628	30.41	3,392	21.93	2,860	3.52
Total ROI Construction	203,749	213,182	4.63	212,477	4.28	220,727	8.33	215,995	6.01	205,070	1.34
Operation											
Bannock County	70,721	70,942	0.31	70,939	0.31	70,927	0.29	70,898	0.25	70,898	0.25
Pocatello	49,357	49,561	0.41	49,558	0.41	49,548	0.39	49,520	0.33	49,520	0.33
Bingham County	40,133	40,503	0.92	40,499	0.91	40,479	0.86	40,430	0.74	40,430	0.74
Blackfoot	10,301	10,596	2.87	10,593	2.84	10,577	2.68	10,538	2.31	10,538	2.31
Bonneville County	75,711	78,861	4.16	78,820	4.11	78,657	3.89	78,236	3.34	78,236	3.34
Idaho Falls	46,061	49,119	6.64	49,080	6.56	48,921	6.21	48,513	5.32	48,513	5.32
Butte County	3,254	3,333	2.43	3,332	2.4	3,328	2.27	3,317	1.93	3,317	1.93
Jefferson County	17,463	17,733	1.54	17,730	1.53	17,716	1.45	17,680	1.24	17,680	1.24
Rigby	2,830	3,034	7.2	3,031	7.1	3,021	6.74	2,993	5.75	2,993	5.75
Total ROI Operation	207,282	211,372	1.97	211,320	1.95	211,107	1.85	210,561	1.58	210,561	1.58

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a.

TABLE D.3-7A.—Changes to Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence

Region of Influence	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Bannock County	69,515	70,480	1.39	70,791	1.84
Pocatello	48,515	48,726	0.43	49,694	2.43
Bingham County	39,449	40,734	3.26	41,591	5.43
Blackfoot	10,125	11,058	9.22	11,834	16.88
Bonneville County	74,420	84,216	13.16	92,641	24.48
Idaho Falls	45,275	54,670	20.75	62,967	39.08
Butte County	3,199	3,450	7.86	3,656	14.3
Jefferson County	17,166	18,053	5.17	18,730	9.11
Rigby	2,782	3,407	22.47	3,961	42.39
Total ROI Construction	203,749	216,933	6.47	227,409	11.61
Operation					
Bannock County	70,721	71,206	0.69	71,278	0.79
Pocatello	49,357	49,572	0.44	49,872	1.04
Bingham County	40,133	40,606	1.18	41,068	2.33
Blackfoot	10,301	10,583	2.74	11,046	7.24
Bonneville County	75,711	78,576	3.78	83,664	10.5
Idaho Falls	46,061	48,723	5.78	53,783	16.77
Butte County	3,254	3,331	2.37	3,454	6.14
Jefferson County	17,463	17,757	1.68	18,146	3.91
Rigby	2,830	3,007	6.25	3,345	18.19
Total ROI Operation	207,282	211,476	2.02	148,543	4.98

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a.

TABLE D.3-8.—Total Housing Units for Idaho National Engineering Laboratory Region of Influence, 1970-2020

Jurisdiction	1970	1980	1990	2005	2010	2020
Bannock County	16,516	24,819	25,694	27,052	27,521	28,567
Pocatello	12,849	18,462	18,768	19,760	20,103	20,866
Bingham County	8,429	12,084	12,664	13,293	13,523	14,037
Blackfoot	2,703	3,707	3,617	3,797	3,862	4,009
Bonneville County	15,683	23,492	26,049	26,847	27,313	28,351
Idaho Falls	11,364	15,053	16,845	17,361	17,662	18,334
Butte County	1,021	1,280	1,265	1,387	1,411	1,464
Jefferson County	3,488	4,994	5,353	5,554	5,651	5,866
Rigby	748	962	969	1,005	1,023	1,062
Total ROI	45,137	66,669	71,025	74,133	75,419	78,285

Source: Census 1972a; Census 1973a; Census 1977a; Census 1982a; Census 1983a; IN Census 1991a.

TABLE D.3-9.—Changes in Housing Demand During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Tritium Supply Technologies for Idaho National Engineering Laboratory Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Bannock County	27,052	27,201	0.55	27,187	0.5	27,356	1.12	27,259	0.77	26,995	0.48
Pocatello	19,760	19,898	0.7	19,885	0.63	20,041	1.42	19,951	0.97	19,719	0.48
Bingham County	13,293	13,544	1.89	13,519	1.71	13,803	3.84	13,641	2.62	13,296	0.71
Blackfoot	3,797	3,997	5.28	3,978	4.77	4,204	10.74	4,074	7.31	3,812	1.1
Bonneville County	26,847	28,983	7.95	28,777	7.19	31,191	16.18	29,806	11.02	27,053	1.46
Idaho Falls	17,361	19,435	11.94	19,235	10.79	21,579	24.3	20,234	16.55	17,578	1.95
Butte County	1,387	1,440	3.85	1,435	3.49	1,496	7.85	1,461	5.36	1,389	0.88
Jefferson County	5,554	5,738	3.3	5,720	2.98	5,928	6.72	5,809	4.58	5,567	0.91
Rigby	1,005	1,144	13.73	1,130	12.41	1,286	27.95	1,197	19.06	1,021	2.21
Total ROI	74,133	76,906	3.74	76,638	3.38	79,774	7.61	77,975	5.18	74,300	0.92
Operation											
Bannock County	27,521	27,556	0.13	27,555	0.12	27,550	0.1	27,539	0.06	27,539	0.06
Pocatello	20,103	20,135	0.16	20,133	0.15	20,129	0.13	20,119	0.08	20,119	0.08
Bingham County	13,523	13,581	0.43	13,579	0.41	13,572	0.36	13,553	0.22	13,553	0.22
Blackfoot	3,862	3,909	1.2	3,907	1.16	3,901	1.01	3,887	0.62	3,887	0.62
Bonneville County	27,313	27,805	1.8	27,789	1.74	27,727	1.52	27,567	0.93	27,567	0.93
Idaho Falls	17,662	18,140	2.7	18,125	2.62	18,064	2.28	17,909	1.4	17,909	1.4
Butte County	1,411	1,423	0.86	1,422	0.83	1,421	0.73	1,417	0.46	1,417	0.46
Jefferson County	5,651	5,693	0.74	5,692	0.72	5,686	0.62	5,672	0.38	5,672	0.38
Rigby	1,023	1,055	3.12	1,054	3.01	1,049	2.6	1,039	1.59	1,039	1.59
Total ROI Operation	75,419	76,057	0.85	76,037	0.82	75,956	0.71	75,749	0.44	75,749	0.44

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN Census 1991a.

TABLE D.3-9A.—Changes in Housing Demand During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence

Region of Influence		No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction						
Bannock County		27,052	27,355	1.12	27,493	1.63
Pocatello		19,760	19,826	0.34	20,168	2.06
Bingham County		13,293	13,696	3.04	14,033	5.57
Blackfoot		3,797	4,089	7.7	4,387	15.56
Bonneville County		26,847	29,919	11.44	33,148	23.47
Idaho Falls		17,361	20,307	16.97	23,479	35.24
Butte County		1,387	1,466	5.69	1,545	11.39
Jefferson County		5,554	5,833	5.01	6,095	9.74
Rigby		1,005	1,202	19.52	1,413	40.58
Total ROI Construction		74,133	78,269	5.58	82,314	11.04
Operation						
Bannock County		27,521	27,636	0.42	27,625	0.38
Pocatello		20,103	20,170	0.34	20,199	0.48
Bingham County		13,523	13,608	0.63	13,698	1.29
Blackfoot		3,862	3,900	0.98	4,002	3.61
Bonneville County		27,313	27,672	1.31	28,799	5.44
Idaho Falls		17,662	17,974	1.76	19,105	8.17
Butte County		1,411	1,422	0.78	1,448	2.64
Jefferson County		5,651	5,697	0.81	5,778	2.26
Rigby		1,023	1,043	1.96	1,119	9.4
Total ROI Operation		75,419	76,035	0.82	77,348	2.56

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995a; DOE 1995b; DOE 1995c; DOE 1995d; DOE 1995e; SNL 1995a; IN Census 1991a.

TABLE D.3-10.—Changes in Housing Demand During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Tritium Supply Technologies and Recycling for Idaho National Engineering Laboratory Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Bannock County	27,052	27,245	0.72	27,231	0.66	27,400	1.29	27,303	0.93	27,034	0.62
Pocatello	19,760	19,939	0.91	19,925	0.84	20,082	1.63	19,992	1.18	19,750	0.64
Bingham County	13,293	13,617	2.44	13,593	2.26	13,877	4.4	13,714	3.17	13,336	1.02
Blackfoot	3,797	4,056	6.82	4,037	6.32	4,263	12.28	4,133	8.86	3,837	1.75
Bonneville County	26,847	29,610	10.29	29,403	9.52	31,819	18.52	30,434	13.36	27,301	2.39
Idaho Falls	17,361	20,043	15.45	19,843	14.3	22,189	27.81	20,843	20.06	17,810	3.3
Butte County	1,387	1,456	5	1,451	4.62	1,512	9.01	1,477	6.48	1,396	1.34
Jefferson County	5,554	5,791	4.27	5,774	3.95	5,981	7.68	5,862	5.54	5,592	1.37
Rigby	1,005	1,184	17.78	1,171	16.45	1,327	32	1,237	23.07	1,036	3.7
Total ROI Construction	74,133	77,720	4.84	77,452	4.48	80,589	8.71	78,790	6.28	74,658	1.4
Operation											
Bannock County	27,521	27,605	0.31	27,604	0.3	27,599	0.28	27,588	0.24	27,588	0.24
Pocatello	20,103	20,180	0.39	20,179	0.38	20,175	0.36	20,165	0.31	20,165	0.31
Bingham County	13,523	13,664	1.04	13,662	1.03	13,655	0.97	13,636	0.83	13,636	0.83
Blackfoot	3,862	3,975	2.91	3,974	2.88	3,968	2.72	3,953	2.34	3,953	2.34
Bonneville County	27,313	28,511	4.39	28,495	4.33	28,433	4.1	28,273	3.52	28,273	3.52
Idaho Falls	17,662	18,825	6.58	18,810	6.5	18,750	6.16	18,595	5.28	18,595	5.28
Butte County	1,411	1,441	2.13	1,440	2.1	1,439	1.99	1,435	1.7	1,435	1.7
Jefferson County	5,651	5,753	1.81	5,752	1.79	5,747	1.7	5,733	1.46	5,733	1.46
Rigby	1,023	1,100	7.58	1,099	7.47	1,095	7.09	1,085	6.05	1,085	6.05
Total ROI Operation	75,419	76,974	2.06	76,954	2.04	76,873	1.93	76,665	1.65	76,665	1.65

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a.

TABLE D.3-10A.—Changes in Housing Demand During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence

Region of Influence		No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction						
Bannock County		27,052	27,419	1.36	27,537	1.79
Pocatello		19,760	19,840	0.41	20,208	2.27
Bingham County		13,293	13,781	3.68	14,107	6.13
Blackfoot		3,797	4,151	9.35	4,446	17.12
Bonneville County		26,847	30,572	13.87	33,775	25.81
Idaho Falls		17,361	20,933	20.58	24,088	38.75
Butte County		1,387	1,482	6.9	1,561	12.54
Jefferson County		5,554	5,892	6.08	6,149	10.71
Rigby		1,005	1,243	23.64	1,454	44.59
Total ROI Construction		74,133	79,146	6.76	83,129	12.14
Operation						
Bannock County		27,521	27,705	0.67	27,733	0.77
Pocatello		20,103	20,184	0.41	20,299	0.97
Bingham County		13,523	13,703	1.33	13,879	2.63
Blackfoot		3,862	3,970	2.78	4,146	7.34
Bonneville County		27,313	28,402	3.99	30,337	11.07
Idaho Falls		17,662	18,675	5.73	20,599	16.62
Butte County		1,411	1,440	2.07	1,487	5.39
Jefferson County		5,651	5,762	1.98	5,910	4.59
Rigby		1,023	1,090	6.57	1,219	19.14
Total ROI Operation		75,419	77,013	2.11	79,346	5.21

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a.

TABLE D.3-11.—County and City Revenues and Expenditures for Idaho National Engineering Laboratory Region of Influence, 1992

Revenues and Expenditures	Bannock County	Pocatello ^a	Bingham County ^a	Blackfoot	Bonneville	Idaho Falls	Butte	Jefferson	Rigby
Property tax (percent)	44	47	44	39	49	54	33	34	42
Intergovernmental (percent)	25	19	31	32	32	25	54	38	40
Permits, fees, fines, and investment interest (percent)	23	12	14	18	15	16	3	16	7
Other (percent)	8	22	11	11	4	5	10	12	12
Total Revenues (dollars)	17,270,189	17,176,656	11,045,505	3,741,621	18,302,511	23,625,020	1,524,987	5,016,650	848,282
General Government (percent)	39	15	28	14	40	9	35	29	23
Public safety, health, and community service (percent)	39	34	39	46	35	43	25	21	24
Public works, parks, culture, and recreation (percent)	21	27	25	24	25	40	37	39	32
Debt service (percent)	0	3	3	1	0	2	0	0	6
Other (percent)	0	21	5	15	0	5	4	11	16
Total Expenditures (dollars)	17,808,705	17,282,164	15,064,797	3,870,197	17,557,221	23,226,057	1,365,238	4,660,790	774,503
End-of-Year Fund Balance (dollars)	8,999,439	5,565,153	2,295,116	929,413	6,645,316	12,855,444	341,780	3,159,247	941,925

^a Estimated from 1989 - 1991 financial audits and 1992 fiscal budgets.

Source: IN City 1992a; IN County 1992a.

TABLE D.3-12.—School District Revenues and Expenditures for Idaho National Engineering Laboratory Region of Influence, 1992

Revenues and Expenditures	Bannock County			Bingham County			Bonneville County			Butte County		Jefferson County		
	Pocatello	Blackfoot	Shelley	Snake River	Bonneville	Falls	Arco	Jefferson	Ririe	Jefferson	West Jefferson			
Property tax (percent)	20	14	21	21	19	28	20	18	14	20	20			
Intergovernmental (percent)	4	3	4	4	5	8	3	4	5	5	5			
Permits, fees, fines, and investment interest (percent)	67	70	67	67	68	59	69	70	77	67	67			
Other (percent)	9	13	8	8	7	6	7	8	4	8	8			
Total Revenues (dollars)	44,626,005	15,004,512	8,105,837	8,194,101	24,411,504	39,495,369	2,874,222	12,246,830	2,711,816	2,980,423	2,980,423			
Total expenditures per pupil (dollars)	3,276	3,387	3,793	3,206	4,360	4,257	3,598	3,315	3,827	3,811	3,811			
Instruction (percent)	59	59	52	57	41	51	57	53	60	53	53			
Support services (percent)	33	35	23	27	20	28	34	24	31	37	37			
Food and community services (percent)	5	5	6	5	3	4	3	5	6	5	5			
Capital assets (percent)	0	1	12	6	31	14	4	7	3	4	4			
Debt service (percent)	2	0	7	5	5	3	2	11	0	4	4			
Total Expenditures (dollars)	45,291,238	15,584,405	8,977,931	7,648,387	32,257,927	41,966,174	2,790,568	12,811,473	2,512,575	2,957,294	2,957,294			
End-of-Year Fund Balance (dollars)	2,347,741	243,702	183,986	1,155,586	2,276,978	4,235,906	365,756	2,724,065	921,078	589,393	589,393			

Source: IN City 1992a; IN County 1992a; IN School 1992a.

TABLE D.3-13.—Changes in County and City Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Bannock County	17,300,653	17,379,360	0.45	17,372,554	0.42	17,452,507	0.88	17,392,824	0.53	17,250,666	0.24
Pocatello	17,738,488	17,806,758	0.38	17,800,707	0.35	17,871,809	0.75	17,816,163	0.44	17,702,185	0.2
Bingham County	11,404,006	11,523,729	1.05	11,513,062	0.96	11,637,966	2.05	11,539,411	1.19	11,420,014	0.53
Blackfoot	3,855,503	3,913,851	1.51	3,909,816	1.41	3,956,944	2.63	3,939,517	2.18	3,880,578	1.05
Bonneville County	17,652,244	18,455,698	4.55	18,380,022	4.12	19,269,859	9.16	18,493,180	4.76	17,920,807	1.97
Idaho Falls	23,088,012	24,337,362	5.41	24,219,381	4.9	25,606,670	10.91	24,390,907	5.64	23,489,418	2.33
Butte County	1,488,215	1,544,878	3.81	1,539,617	3.45	1,604,375	7.81	1,544,814	3.8	1,502,905	1.58
Jefferson County	4,741,700	4,814,833	1.54	4,808,184	1.4	4,885,596	3.03	4,822,800	1.71	4,758,667	0.73
Rigby	822,765	839,930	2.09	838,256	1.88	857,735	4.25	840,086	2.11	825,060	0.85
Total ROI	98,091,586	100,616,399	2.57	100,381,600	2.33	103,143,459	5.15	100,779,703	2.74	98,750,299	1.15
Revenues											
Expenditures											
Bannock County	17,686,173	17,710,968	0.14	17,708,570	0.13	17,736,778	0.29	17,711,288	0.14	17,666,289	0.06
Pocatello	17,486,430	17,564,856	0.45	17,557,271	0.41	17,646,493	0.92	17,565,868	0.45	17,424,283	0.19
Bingham County	11,372,761	11,489,695	1.03	11,478,360	0.93	11,611,187	2.1	11,490,807	1.04	11,372,968	0.43
Blackfoot	3,793,678	3,840,687	1.24	3,836,131	1.12	3,889,529	2.53	3,841,134	1.25	3,789,972	0.51
Bonneville County	17,721,518	18,132,553	2.32	18,092,887	2.1	18,559,362	4.73	18,136,992	2.34	17,851,496	0.95
Idaho Falls	23,755,117	24,241,662	2.05	24,194,709	1.85	24,746,877	4.17	24,246,916	2.07	23,909,665	0.83
Butte County	1,443,508	1,485,278	2.89	1,481,400	2.62	1,529,136	5.93	1,485,230	2.89	1,454,337	1.2
Jefferson County	4,797,349	4,915,410	2.46	4,903,898	2.22	5,037,880	5.01	4,916,488	2.48	4,816,238	1
Rigby	842,701	847,953	0.62	847,441	0.56	853,401	1.27	848,001	0.63	845,574	0.25
Total ROI	98,899,235	100,229,062	1.34	100,100,667	1.21	101,610,643	2.74	100,242,724	1.36	99,130,821	0.55
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN Census 1991a; IN City 1992a; IN County 1992a; IN DOC 1991a.

TABLE D.3-13A.—Changes in County and City Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Bannock County	17,300,653	17,399,797	0.57	17,520,671	1.27
Pocatello	17,738,488	17,822,040	0.47	17,928,880	1.07
Bingham County	11,404,006	11,549,656	1.28	11,737,718	2.93
Blackfoot	3,855,503	3,945,874	2.34	4,021,701	4.31
Bonneville County	17,652,244	18,556,803	5.12	19,879,244	12.62
Idaho Falls	23,088,012	24,489,482	6.07	26,550,003	14.99
Butte County	1,488,215	1,549,096	4.09	1,645,504	10.57
Jefferson County	4,741,700	4,828,936	1.84	4,945,142	4.29
Rigby	822,765	841,397	2.26	870,167	5.76
Total ROI County and City Revenues	98,091,586	100,983,080	2.95	105,099,028	7.14
Expenditures					
Bannock County	17,686,173	17,713,188	0.15	17,754,707	0.39
Pocatello	17,486,430	17,571,878	0.49	17,703,206	1.24
Bingham County	11,372,761	11,499,738	1.12	11,695,893	2.84
Blackfoot	3,793,678	3,844,725	1.35	3,923,582	3.42
Bonneville County	17,721,518	18,168,426	2.52	18,857,910	6.41
Idaho Falls	23,755,117	24,284,124	2.23	25,100,269	5.66
Butte County	1,443,508	1,488,387	3.11	1,559,455	8.03
Jefferson County	4,797,349	4,925,502	2.67	5,123,389	6.8
Rigby	842,701	848,402	0.68	857,205	1.72
Total ROI County and City Expenditures	98,899,235	100,344,370	1.46	102,575,616	3.72

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN Census 1991a; IN City 1992a; IN County 1992a; IN DOC 1991a.

TABLE D.3-14.—Changes to County and City Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Bannock County	17,495,800	17,516,300	0.12	17,515,695	0.11	17,510,984	0.09	17,507,324	0.07	17,507,324	0.07
Pocatello	17,917,798	17,935,160	0.1	17,934,636	0.09	17,930,569	0.07	17,927,404	0.05	17,927,404	0.05
Bingham County	11,515,415	11,545,737	0.26	11,544,819	0.26	11,537,628	0.19	11,532,254	0.15	11,532,254	0.15
Blackfoot	3,894,581	3,912,816	0.47	3,912,355	0.46	3,908,703	0.36	3,905,939	0.29	3,905,939	0.29
Bonneville County	17,836,074	18,026,992	1.07	18,021,095	1.04	17,973,552	0.77	17,936,995	0.57	17,936,995	0.57
Idaho Falls	23,374,411	23,670,313	1.27	23,661,149	1.23	23,587,276	0.91	23,530,467	0.67	23,530,467	0.67
Butte County	1,510,543	1,523,495	0.86	1,523,090	0.83	1,519,852	0.62	1,517,424	0.46	1,517,424	0.46
Jefferson County	4,784,517	4,802,793	0.38	4,802,319	0.37	4,797,863	0.28	4,794,468	0.21	4,794,468	0.21
Rigby	833,450	837,403	0.47	837,296	0.46	836,263	0.34	835,480	0.24	835,480	0.24
Total ROI	99,162,589	99,771,008	0.61	99,752,454	0.59	99,602,690	0.44	99,487,755	0.33	99,487,755	0.33
Revenues											
Expenditures											
Bannock County	17,762,280	17,768,014	0.03	17,767,825	0.03	17,766,374	0.02	17,765,238	0.02	17,765,238	0.02
Pocatello	17,727,414	17,745,551	0.1	17,744,952	0.1	17,740,361	0.07	17,736,768	0.05	17,736,768	0.05
Bingham County	11,494,117	11,521,009	0.23	11,520,123	0.23	11,513,216	0.17	11,508,080	0.12	11,508,080	0.12
Blackfoot	3,841,961	3,852,772	0.28	3,852,416	0.27	3,849,639	0.2	3,847,574	0.15	3,847,574	0.15
Bonneville County	17,815,897	17,910,549	0.53	17,907,548	0.51	17,883,397	0.38	17,864,809	0.27	17,864,809	0.27
Idaho Falls	23,864,119	23,976,158	0.47	23,972,606	0.45	23,944,019	0.33	23,922,015	0.24	23,922,015	0.24
Butte County	1,459,933	1,469,481	0.65	1,469,182	0.63	1,466,796	0.47	1,465,005	0.35	1,465,005	0.35
Jefferson County	4,870,096	4,897,285	0.56	4,896,550	0.54	4,889,446	0.4	4,884,058	0.29	4,884,058	0.29
Rigby	846,664	847,874	0.14	847,841	0.14	847,525	0.1	847,285	0.07	847,285	0.07
Total ROI	99,682,481	99,988,691	0.31	99,979,043	0.3	99,900,773	0.22	99,840,833	0.16	99,840,833	0.16
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN Census 1991a; IN City 1992a; IN County 1992a; IN DOC 1991a.

TABLE D.3-14A.—Changes to County and City Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Bannock County	17,495,800	17,511,688	0.09	17,560,459	0.37
Pocatello	17,917,798	17,930,994	0.07	17,972,522	0.31
Bingham County	11,515,415	11,538,394	0.2	11,610,979	0.83
Blackfoot	3,894,581	3,910,515	0.41	3,952,345	1.48
Bonneville County	17,836,074	17,973,860	0.77	18,437,393	3.37
Idaho Falls	23,374,411	23,587,369	0.91	24,306,310	3.99
Butte County	1,510,543	1,519,982	0.62	1,551,321	2.7
Jefferson County	4,784,517	4,798,344	0.29	4,842,374	1.21
Rigby	833,450	836,243	0.34	845,949	1.5
Total ROI County and City Revenues	99,162,589	99,607,389	0.45	101,079,652	1.93
Expenditures					
Bannock County	17,762,280	17,766,276	0.02	17,780,301	0.1
Pocatello	17,727,414	17,740,051	0.07	17,784,412	0.32
Bingham County	11,494,117	11,512,830	0.16	11,578,636	0.74
Blackfoot	3,841,961	3,849,484	0.2	3,875,939	0.88
Bonneville County	17,815,897	17,882,354	0.37	18,113,762	1.67
Idaho Falls	23,864,119	23,942,783	0.33	24,216,703	1.48
Butte County	1,459,933	1,466,891	0.48	1,489,993	2.06
Jefferson County	4,870,096	4,889,309	0.39	4,956,070	1.77
Rigby	846,664	847,519	0.1	850,489	0.45
Total ROI County and City Expenditures	99,682,481	99,897,497	0.22	100,646,304	0.97

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN Census 1991a; IN City 1992a; IN County 1992a; IN DOC 1991a.

TABLE D.3-15.—Changes to School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Arco	3,005,283	3,053,956	1.62	3,049,880	1.48	3,099,741	3.14	3,057,763	1.75	3,042,657	0.25
Blackfoot	15,987,856	16,255,445	1.67	16,229,507	1.51	16,533,469	3.41	16,240,219	1.58	16,239,408	0.21
Bonneville	28,642,438	30,626,604	6.93	30,444,417	6.29	32,586,402	13.77	30,650,324	7.01	29,657,165	0.96
Idaho Falls	41,388,574	44,683,027	7.96	44,388,652	7.25	47,849,123	15.61	44,839,808	8.34	43,440,660	1.16
Jefferson	12,764,278	13,140,238	2.95	13,105,290	2.67	13,512,109	5.86	13,143,023	2.97	13,062,537	0.4
Pocatello	47,015,081	47,280,774	0.57	47,255,078	0.51	47,557,342	1.15	47,266,496	0.53	47,544,861	0.07
Ririe	2,546,424	2,570,450	0.94	2,568,615	0.87	2,589,999	1.71	2,576,284	1.17	2,570,694	0.18
Shelley	9,604,500	9,753,568	1.55	9,739,767	1.41	9,901,482	3.09	9,754,393	1.56	9,729,816	0.21
Snake River	8,385,061	8,440,562	0.66	8,435,908	0.61	8,490,432	1.26	8,447,819	0.75	8,451,831	0.11
West Jefferson	3,110,676	3,203,007	2.97	3,194,490	2.69	3,293,636	5.88	3,204,626	3.02	3,184,954	0.41
Total ROI	172,450,171	179,007,631	3.80	178,411,604	3.46	185,413,734	7.52	179,180,754	3.9	176,924,582	0.54
Revenues											
Expenditures											
Arco	2,942,204	3,066,443	4.22	3,054,906	3.83	3,196,893	8.66	3,058,136	3.94	3,018,885	0.53
Blackfoot	15,344,053	15,518,829	1.14	15,501,888	1.03	15,700,420	2.32	15,508,885	1.07	15,483,328	0.14
Bonneville	28,377,490	29,968,505	5.61	29,814,969	5.07	31,620,573	11.43	29,879,884	5.29	29,062,455	0.69
Idaho Falls	40,023,608	42,705,819	6.7	42,446,981	6.05	45,490,955	13.66	42,556,418	6.33	41,344,748	0.83
Jefferson	12,385,854	12,690,706	2.46	12,660,980	2.22	13,006,944	5.01	12,673,250	2.32	12,588,293	0.30
Pocatello	46,998,053	47,245,810	0.53	47,221,849	0.48	47,503,709	1.08	47,232,496	0.5	47,479,309	0.07
Ririe	2,614,477	2,685,319	2.71	2,678,411	2.45	2,758,806	5.52	2,681,263	2.55	2,677,386	0.33
Shelley	10,262,219	10,389,417	1.24	10,377,087	1.12	10,521,574	2.53	10,382,179	1.17	10,296,221	0.15
Snake River	8,088,610	8,207,597	1.47	8,196,064	1.33	8,331,224	3	8,200,827	1.39	8,187,012	0.18
West Jefferson	3,046,831	3,128,895	2.69	3,120,893	2.43	3,214,022	5.49	3,124,196	2.54	3,105,981	0.33
Total ROI	170,083,400	175,607,340	3.25	175,074,027	2.93	181,345,119	6.62	175,297,533	3.07	173,243,617	0.4
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN Census 1991a; IN DOC 1991a; IN School 1992a.

TABLE D.3-15A.—Changes to School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Arco	3,005,283	3,065,709	2.01	3,141,750	4.54
Blackfoot	15,987,856	16,278,429	1.82	16,727,310	4.63
Bonneville	28,642,438	30,954,335	8.07	34,156,495	19.25
Idaho Falls	41,388,574	45,362,354	9.6	50,568,814	22.18
Jefferson	12,764,278	13,200,369	3.42	13,807,775	8.18
Pocatello	47,015,081	47,304,562	0.62	47,749,471	1.56
Ririe	2,546,424	2,580,805	1.35	2,614,330	2.67
Shelley	9,604,500	9,777,088	1.8	10,018,416	4.31
Snake River	8,385,061	8,457,321	0.86	8,540,651	1.86
West Jefferson	3,110,676	3,218,851	3.48	3,367,146	8.24
Total ROI Revenues	172,450,171	180,199,821	4.49	190,692,156	10.58
Expenditures					
Arco	2,942,204	3,075,690	4.54	3,287,072	11.72
Blackfoot	15,344,053	15,533,841	1.24	15,827,027	3.15
Bonneville	28,377,490	30,107,360	6.1	32,776,177	15.5
Idaho Falls	40,023,608	42,939,907	7.29	47,439,129	18.53
Jefferson	12,385,854	12,716,764	2.67	13,227,741	6.8
Pocatello	46,998,053	47,267,992	0.57	47,682,868	1.46
Ririe	2,614,477	2,691,374	2.94	2,810,115	7.48
Shelley	10,262,219	10,400,342	1.35	10,613,715	3.43
Snake River	8,088,610	8,217,817	1.6	8,417,417	4.07
West Jefferson	3,046,831	3,135,909	2.92	3,273,459	7.44
Total ROI Expenditures	170,083,400	176,086,996	3.53	185,354,720	8.98

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN Census 1991a; IN DOC 1991a; IN School 1992a.

TABLE D.3-16.—Changes to School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Arco	3,029,757	3,042,880	0.43	3,042,510	0.42	3,039,545	0.32	3,037,320	0.25	3,037,320	0.25
Blackfoot	16,265,237	16,326,775	0.38	16,324,749	0.37	16,308,943	0.27	16,297,189	0.2	16,297,189	0.2
Bonneville	29,145,644	29,640,791	1.7	29,625,931	1.65	29,506,117	1.24	29,414,143	0.92	29,414,143	0.92
Idaho Falls	42,326,502	43,182,076	2.02	43,157,072	1.96	42,955,310	1.49	42,800,639	1.12	42,800,639	1.12
Jefferson	13,017,612	13,111,104	0.72	13,108,658	0.7	13,085,503	0.52	13,067,951	0.39	13,067,951	0.39
Pocatello	47,830,642	47,892,085	0.13	47,890,056	0.12	47,874,503	0.09	47,862,332	0.07	47,862,332	0.07
Ririe	2,566,733	2,574,315	0.3	2,574,135	0.29	2,572,530	0.23	2,571,317	0.18	2,571,317	0.18
Shelley	9,786,330	9,823,262	0.38	9,822,111	0.37	9,813,086	0.27	9,806,367	0.2	9,806,367	0.2
Snake River	8,459,527	8,475,257	0.19	8,474,812	0.18	8,471,288	0.14	8,468,657	0.11	8,468,657	0.11
West Jefferson	3,173,725	3,196,951	0.73	3,196,347	0.71	3,190,639	0.53	3,186,314	0.4	3,186,314	0.4
Total ROI	175,601,709	177,265,496	0.95	177,216,380	0.92	176,817,465	0.69	176,512,229	0.52	176,512,229	0.52
Revenues											
Expenditures											
Arco	2,990,995	3,019,393	0.95	3,018,505	0.92	3,011,406	0.68	3,006,082	0.5	3,006,082	0.5
Blackfoot	15,523,365	15,563,559	0.26	15,562,235	0.25	15,551,912	0.18	15,544,235	0.13	15,544,235	0.13
Bonneville	28,724,762	29,091,134	1.28	29,079,519	1.24	28,986,038	0.91	28,914,086	0.66	28,914,086	0.66
Idaho Falls	40,629,058	41,246,704	1.52	41,227,124	1.47	41,069,529	1.08	40,948,229	0.79	40,948,229	0.79
Jefferson	12,572,160	12,642,365	0.56	12,640,468	0.54	12,622,126	0.4	12,608,212	0.29	12,608,212	0.29
Pocatello	47,757,386	47,814,681	0.12	47,812,790	0.12	47,798,287	0.09	47,786,937	0.06	47,786,937	0.06
Ririe	2,658,277	2,674,591	0.61	2,674,150	0.6	2,669,888	0.44	2,666,655	0.32	2,666,655	0.32
Shelley	10,384,108	10,413,360	0.28	10,412,397	0.27	10,404,884	0.2	10,399,297	0.15	10,399,297	0.15
Snake River	8,210,458	8,237,821	0.33	8,236,920	0.32	8,229,892	0.24	8,224,666	0.17	8,224,666	0.17
West Jefferson	3,097,371	3,116,270	0.61	3,115,759	0.59	3,110,822	0.43	3,107,076	0.31	3,107,076	0.31
Total ROI	172,547,942	173,819,879	0.74	173,779,868	0.71	173,454,783	0.53	173,205,473	0.38	173,205,473	0.38
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN Census 1991a; IN DOC 1991a; IN School 1992a.

TABLE D.3-16A.—Changes to School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence

	Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues						
Arco		3,029,757	3,040,290	0.35	3,071,204	1.37
Blackfoot		16,265,237	16,308,059	0.26	16,458,650	1.19
Bonneville		29,145,644	29,514,205	1.26	30,706,576	5.36
Idaho Falls		42,326,502	42,980,220	1.54	45,025,857	6.38
Jefferson		13,017,612	13,087,389	0.54	13,313,512	2.27
Pocatello		47,830,642	47,873,454	0.09	48,023,738	0.4
Ririe		2,566,733	2,573,191	0.25	2,590,788	0.94
Shelley		9,786,330	9,813,513	0.28	9,902,618	1.19
Snake River		8,459,527	8,472,133	0.15	8,509,202	0.59
West Jefferson		3,173,725	3,191,192	0.55	3,247,245	2.32
Total ROI Revenues		175,601,709	176,853,646	0.71	180,849,391	2.99
Expenditures						
Arco		2,990,995	3,011,690	0.69	3,080,403	2.99
Blackfoot		15,523,365	15,551,335	0.18	15,649,693	0.81
Bonneville		28,724,762	28,981,998	0.9	29,877,723	4.01
Idaho Falls		40,629,058	41,062,718	1.07	42,572,775	4.78
Jefferson		12,572,160	12,621,772	0.39	12,794,159	1.77
Pocatello		47,757,386	47,797,308	0.08	47,937,448	0.38
Ririe		2,658,277	2,669,806	0.43	2,709,865	1.94
Shelley		10,384,108	10,404,464	0.2	10,476,046	0.89
Snake River		8,210,458	8,229,499	0.23	8,296,461	1.05
West Jefferson		3,097,371	3,110,726	0.43	3,157,131	1.93
Total ROI Expenditures		172,547,942	173,441,315	0.52	176,551,703	2.32

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; IN Census 1991a; IN DOC 1991a; IN School 1992a.

TABLE D.3-17.—Changes to County and City Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies and Recycling for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Bannock County	17,300,653	17,400,105	0.57	17,393,310	0.54	17,472,946	1	17,412,872	0.65	17,270,557	0.35
Pocatello	17,738,488	17,825,207	0.49	17,819,164	0.45	17,889,975	0.85	17,833,401	0.54	17,719,165	0.29
Bingham County	11,404,006	11,556,033	1.33	11,545,386	1.24	11,669,813	2.33	11,569,960	1.46	11,450,665	0.8
Blackfoot	3,855,503	3,926,034	1.83	3,922,032	1.73	3,969,011	2.94	3,955,531	2.59	3,896,794	1.48
Bonneville County	17,652,244	18,685,917	5.86	18,610,115	5.43	19,497,079	10.45	18,693,776	5.90	18,121,320	3.11
Idaho Falls	23,088,012	24,696,279	6.97	24,578,101	6.45	25,960,901	12.44	24,702,544	6.99	23,800,897	3.69
Butte County	1,488,215	1,561,877	4.95	1,556,211	4.57	1,620,969	8.92	1,559,481	4.79	1,516,251	2.48
Jefferson County	4,741,700	4,834,781	1.96	4,828,263	1.83	4,905,432	3.45	4,841,243	2.1	4,777,245	1.12
Rigby	822,765	844,951	2.7	843,313	2.5	862,721	4.86	844,307	2.62	829,305	1.37
Total ROI	98,091,586	101,331,184	3.3	101,095,895	3.06	103,848,846	5.87	101,413,115	3.39	99,382,200	1.8
Expenditures											
Bannock County	17,686,173	17,718,288	0.18	17,715,890	0.17	17,743,972	0.33	17,717,342	0.18	17,672,263	0.09
Pocatello	17,486,430	17,588,010	0.58	17,580,425	0.54	17,669,248	1.05	17,585,017	0.56	17,443,099	0.3
Bingham County	11,372,761	11,524,053	1.33	11,512,718	1.23	11,645,014	2.39	11,519,758	1.29	11,402,021	0.68
Blackfoot	3,793,678	3,854,500	1.6	3,849,943	1.48	3,903,128	2.89	3,852,773	1.56	3,801,698	0.82
Bonneville County	17,721,518	18,253,233	3	18,213,495	2.78	18,678,432	5.4	18,238,728	2.92	17,953,098	1.52
Idaho Falls	23,755,117	24,384,511	2.65	24,337,472	2.45	24,887,820	4.77	24,367,341	2.58	24,029,931	1.34
Butte County	1,443,508	1,497,809	3.76	1,493,632	3.47	1,541,369	6.78	1,496,043	3.64	1,464,175	1.88
Jefferson County	4,797,349	4,949,947	3.18	4,938,679	2.95	5,072,172	5.73	4,945,518	3.09	4,845,437	1.61
Rigby	842,701	849,490	0.81	848,988	0.75	854,927	1.45	849,292	0.78	846,873	0.41
Total ROI	98,899,235	100,619,840	1.74	100,491,243	1.61	101,996,081	3.13	100,571,813	1.69	99,458,595	0.88
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a; IN City 1992a; IN County 1992a; IN DOC 1991a.

TABLE D.3-17A.—Changes to County and City Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Bannock County	17,300,653	17,419,589	0.69	17,571,212	1.56
Pocatello	17,738,488	17,839,082	0.57	17,974,062	1.33
Bingham County	11,404,006	11,579,894	1.54	11,816,834	3.62
Blackfoot	3,855,503	3,961,519	2.75	4,049,768	5.04
Bonneville County	17,652,244	18,756,121	6.25	20,449,228	15.84
Idaho Falls	23,088,012	24,799,189	7.41	27,439,073	18.85
Butte County	1,488,215	1,563,747	5.08	1,686,763	13.34
Jefferson County	4,741,700	4,847,201	2.22	4,994,466	5.33
Rigby	822,765	845,596	2.77	882,764	7.29
Total ROI Revenues	98,091,586	101,611,938	3.59	106,864,170	8.94
Expenditures					
Bannock County	17,686,173	17,719,207	0.19	17,772,947	0.49
Pocatello	17,486,430	17,590,919	0.6	17,760,897	1.57
Bingham County	11,372,761	11,528,557	1.37	11,781,435	3.59
Blackfoot	3,793,678	3,856,310	1.65	3,957,971	4.33
Bonneville County	17,721,518	18,269,688	3.09	19,158,090	8.11
Idaho Falls	23,755,117	24,403,989	2.73	25,455,595	7.16
Butte County	1,443,508	1,499,187	3.86	1,589,870	10.14
Jefferson County	4,797,349	4,954,387	3.27	5,210,034	8.6
Rigby	842,701	849,687	0.83	861,060	2.18
Total ROI Expenditures	98,899,235	100,671,932	1.79	103,547,897	4.7

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a; IN City 1992a; IN County 1992a; IN DOC 1991a.

TABLE D.3-18.—Changes to County and City Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies and Recycling for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Bannock County	17,495,800	17,542,876	0.27	17,542,271	0.27	17,539,842	0.25	17,533,890	0.22	17,533,890	0.22
Pocatello	17,917,798	17,958,114	0.23	17,957,591	0.22	17,955,488	0.21	17,950,351	0.18	17,950,351	0.18
Bingham County	11,515,415	11,585,975	0.61	11,585,210	0.61	11,581,538	0.57	11,572,492	0.5	11,572,492	0.50
Blackfoot	3,894,581	3,933,305	0.99	3,932,882	0.98	3,931,037	0.94	3,926,429	0.82	3,926,429	0.82
Bonneville County	17,836,074	18,294,419	2.57	18,288,523	2.54	18,265,040	2.41	18,204,422	2.07	18,204,422	2.07
Idaho Falls	23,374,411	24,085,863	3.04	24,076,699	3	24,040,212	2.85	23,946,017	2.45	23,946,017	2.45
Butte County	1,510,543	1,542,518	2.12	1,542,113	2.09	1,540,494	1.98	1,536,042	1.69	1,536,042	1.69
Jefferson County	4,784,517	4,827,315	0.89	4,826,841	0.88	4,824,679	0.84	4,819,122	0.72	4,819,122	0.72
Rigby	833,450	843,065	1.15	842,958	1.14	842,460	1.08	841,178	0.93	841,178	0.93
Total ROI	99,162,589	100,613,451	1.46	100,595,087	1.44	100,520,789	1.37	100,329,942	1.18	100,329,942	1.18
Expenditures											
Bannock County	17,762,280	17,776,218	0.08	17,776,029	0.08	17,775,271	0.07	17,773,441	0.06	17,773,441	0.06
Pocatello	17,727,414	17,771,499	0.25	17,770,900	0.25	17,768,505	0.23	17,762,717	0.2	17,762,717	0.2
Bingham County	11,494,117	11,559,617	0.57	11,558,909	0.56	11,555,367	0.53	11,546,688	0.46	11,546,688	0.46
Blackfoot	3,841,961	3,868,293	0.69	3,868,008	0.68	3,866,584	0.64	3,863,095	0.55	3,863,095	0.55
Bonneville County	17,815,897	18,046,451	1.29	18,043,451	1.28	18,031,522	1.21	18,000,711	1.04	18,000,711	1.04
Idaho Falls	23,864,119	24,137,026	1.14	24,133,474	1.13	24,119,354	1.07	24,082,884	0.92	24,082,884	0.92
Butte County	1,459,933	1,483,503	1.61	1,483,205	1.59	1,482,012	1.51	1,478,730	1.29	1,478,730	1.29
Jefferson County	4,870,096	4,936,230	1.36	4,935,495	1.34	4,932,066	1.27	4,923,248	1.09	4,923,248	1.09
Rigby	846,664	849,606	0.35	849,574	0.34	849,421	0.33	849,029	0.28	849,029	0.28
Total ROI	99,682,481	100,428,444	0.75	100,419,044	0.74	100,380,101	0.7	100,280,543	0.6	100,280,543	0.6
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a; IN City 1992a; IN County 1992a; IN DOC 1991a.

**TABLE D.3-18A.—Changes to County and City Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence**

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Bannock County	17,495,800	17,562,692	0.38	17,617,555	0.7
Pocatello	17,917,798	17,974,855	0.32	18,022,054	0.58
Bingham County	11,515,415	11,615,320	0.87	11,698,278	1.59
Blackfoot	3,894,581	3,951,240	1.45	3,994,931	2.58
Bonneville County	17,836,074	18,477,616	3.6	19,021,489	6.65
Idaho Falls	23,374,411	24,369,705	4.26	25,214,406	7.87
Butte County	1,510,543	1,555,162	2.95	1,593,255	5.48
Jefferson County	4,784,517	4,844,978	1.26	4,895,406	2.32
Rigby	833,450	846,857	1.61	858,361	2.99
Total ROI Revenues	99,162,589	101,198,424	2.05	102,915,735	3.78
Expenditures					
Bannock County	17,762,280	17,781,689	0.11	17,798,301	0.2
Pocatello	17,727,414	17,788,803	0.35	17,841,348	0.64
Bingham County	11,494,117	11,585,415	0.79	11,663,871	1.48
Blackfoot	3,841,961	3,878,664	0.96	3,910,204	1.78
Bonneville County	17,815,897	18,136,986	1.8	18,412,087	3.35
Idaho Falls	23,864,119	24,244,192	1.59	24,569,831	2.96
Butte County	1,459,933	1,492,824	2.25	1,520,905	4.18
Jefferson County	4,870,096	4,962,311	1.89	5,041,441	3.52
Rigby	846,664	850,767	0.48	854,287	0.9
Total ROI Expenditures	99,682,481	100,721,651	1.04	101,612,275	1.94

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a; IN City 1992a; IN County 1992a; IN DOC 1991a.

TABLE D.3-19.—Changes to School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies and Recycling for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Arco	3,005,283	3,067,029	2.05	3,062,678	1.91	3,112,542	3.57	3,074,402	2.3	3,032,734	1.24
Blackfoot	15,987,856	16,334,070	2.17	16,308,132	2	16,610,877	3.9	16,324,242	2.1	16,053,571	1.10
Bonneville	28,642,438	31,180,853	8.86	30,998,372	8.23	33,133,702	15.68	31,291,608	9.25	29,849,774	4.93
Idaho Falls	41,388,574	45,578,535	10.12	45,283,723	9.41	48,733,811	17.75	45,920,522	10.95	43,446,756	5.9
Jefferson	12,764,278	13,245,139	3.77	13,210,905	3.5	13,616,314	6.68	13,263,783	3.91	12,928,666	2.09
Pocatello	47,015,081	47,359,214	0.73	47,333,518	0.68	47,634,430	1.32	47,349,074	0.71	46,866,027	0.37
Ririe	2,546,424	2,575,973	1.16	2,574,168	1.09	2,595,497	1.93	2,584,781	1.51	2,554,991	0.84
Shelley	9,604,500	9,795,406	1.99	9,781,606	1.84	9,942,708	3.52	9,802,461	2.06	9,676,163	1.1
Snake River	8,385,061	8,454,674	0.83	8,450,021	0.77	8,504,365	1.42	8,466,657	0.97	8,400,630	0.53
West Jefferson	3,110,676	3,228,574	3.79	3,220,230	3.52	3,319,035	6.7	3,234,412	3.98	3,151,480	2.13
Total ROI	172,450,171	180,819,466	4.85	180,223,352	4.51	187,203,281	8.55	181,311,941	5.14	175,960,792	2.75
Revenues											
Expenditures											
Arco	2,942,204	3,103,714	5.49	3,091,290	5.07	3,233,277	9.89	3,098,461	5.31	3,002,286	2.76
Blackfoot	15,344,053	15,570,183	1.47	15,553,242	1.36	15,750,979	2.65	15,563,764	1.43	15,374,048	0.75
Bonneville	28,377,490	30,435,628	7.25	30,281,809	6.71	32,081,464	13.05	30,379,482	7.05	29,179,074	3.7
Idaho Falls	40,023,608	43,493,317	8.67	43,234,001	8.02	46,267,947	15.6	43,398,664	8.43	41,474,061	4.42
Jefferson	12,385,854	12,779,885	3.18	12,750,792	2.95	13,095,490	5.73	12,768,450	3.09	12,496,111	1.62
Pocatello	46,998,053	47,318,955	0.68	47,294,994	0.63	47,575,593	1.23	47,309,500	0.66	46,854,164	0.35
Ririe	2,614,477	2,706,042	3.5	2,699,282	3.24	2,779,383	6.31	2,703,385	3.4	2,644,009	1.78
Shelley	10,262,219	10,426,790	1.6	10,414,461	1.48	10,558,370	2.89	10,422,119	1.56	10,291,863	0.82
Snake River	8,088,610	8,242,559	1.9	8,231,025	1.76	8,365,644	3.42	8,238,189	1.85	8,117,599	0.97
West Jefferson	3,046,831	3,152,901	3.48	3,145,069	3.22	3,237,858	6.27	3,149,822	3.38	3,080,139	1.77
Total ROI	170,083,400	177,229,974	4.2	176,695,963	3.89	182,946,005	7.56	177,031,835	4.09	172,513,353	2.14
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a; IN DOC 1991a; IN School 192a.

TABLE D.3-19A.—Changes to School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Arco	3,005,283	3,078,540	2.44	3,172,875	5.58
Blackfoot	15,987,856	16,344,378	2.23	16,923,063	5.85
Bonneville	28,642,438	31,450,185	9.8	35,521,766	24.02
Idaho Falls	41,388,574	46,191,801	11.61	52,762,409	27.48
Jefferson	12,764,278	13,293,683	4.15	14,068,428	10.22
Pocatello	47,015,081	47,369,066	0.75	47,944,916	1.98
Ririe	2,546,424	2,587,077	1.6	2,627,438	3.18
Shelley	9,604,500	9,814,310	2.18	10,121,649	5.38
Snake River	8,385,061	8,471,541	1.03	8,574,744	2.26
West Jefferson	3,110,676	3,241,818	4.22	3,430,571	10.28
Total ROI Revenues	172,450,171	181,842,399	5.45	195,147,858	13.16
Expenditures					
Arco	2,942,204	3,107,814	5.63	3,377,536	14.8
Blackfoot	15,344,053	15,576,916	1.52	15,954,883	3.98
Bonneville	28,377,490	30,499,320	7.48	33,938,102	19.6
Idaho Falls	40,023,608	43,600,691	8.94	49,397,957	23.42
Jefferson	12,385,854	12,791,352	3.27	13,451,472	8.6
Pocatello	46,998,053	47,328,143	0.7	47,865,119	1.84
Ririe	2,614,477	2,708,707	3.6	2,862,106	9.47
Shelley	10,262,219	10,431,690	1.65	10,706,765	4.33
Snake River	8,088,610	8,247,142	1.96	8,504,461	5.14
West Jefferson	3,046,831	3,155,987	3.58	3,333,685	9.41
Total ROI Expenditures	170,083,400	177,447,762	4.33	189,392,085	11.35

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a; IN DOC 1991a; IN School 192a.

TABLE D.3-20.—Changes in School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies and Recycling for Idaho National Engineering Laboratory Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Arco	3,029,757	3,060,074	1.00	3,059,704	0.99	3,058,229	0.94	3,054,236	0.81	3,054,236	0.81
Blackfoot	16,265,237	16,415,126	0.92	16,413,505	0.91	16,405,400	0.86	16,385,541	0.74	16,385,541	0.74
Bonneville	29,145,644	30,314,284	4.01	30,299,423	3.96	30,240,294	3.76	30,087,634	3.23	30,087,634	3.23
Idaho Falls	42,326,502	44,315,592	4.70	44,290,589	4.64	44,191,061	4.41	43,934,152	3.80	43,934,152	3.80
Jefferson	13,017,612	13,238,305	1.70	13,235,859	1.68	13,224,661	1.59	13,195,861	1.37	13,195,861	1.37
Pocatello	47,830,642	47,979,992	0.31	47,977,963	0.31	47,969,849	0.29	47,950,239	0.25	47,950,239	0.25
Ririe	2,566,733	2,583,185	0.64	2,583,004	0.63	2,582,223	0.60	2,580,215	0.53	2,580,215	0.53
Shelley	9,786,330	9,873,695	0.89	9,872,750	0.88	9,868,144	0.84	9,856,799	0.72	9,856,799	0.72
Snake River	8,459,527	8,494,941	0.42	8,494,558	0.41	8,492,775	0.39	8,488,341	0.34	8,488,341	0.34
West Jefferson	3,173,725	3,228,312	1.72	3,227,708	1.70	3,224,947	1.61	3,217,846	1.39	3,217,846	1.39
Total ROI	175,601,709	179,503,504	2.22	179,455,062	2.19	179,257,582	2.08	178,750,864	1.79	178,750,864	1.79
Revenues											
Expenditures											
Arco	2,990,995	3,061,101	2.34	3,060,214	2.31	3,056,664	2.20	3,046,903	1.87	3,046,903	1.87
Blackfoot	15,523,365	15,621,265	0.63	15,620,207	0.62	15,614,912	0.59	15,601,942	0.51	15,601,942	0.51
Bonneville	28,724,762	29,617,178	3.11	29,605,564	3.07	29,559,390	2.91	29,440,130	2.49	29,440,130	2.49
Idaho Falls	40,629,058	42,133,535	3.70	42,113,955	3.65	42,036,113	3.46	41,835,060	2.97	41,835,060	2.97
Jefferson	12,572,160	12,742,929	1.36	12,741,031	1.34	12,732,177	1.27	12,709,408	1.09	12,709,408	1.09
Pocatello	47,757,386	47,896,654	0.29	47,894,762	0.29	47,887,196	0.27	47,868,909	0.23	47,868,909	0.23
Ririe	2,658,277	2,697,960	1.49	2,697,519	1.48	2,695,462	1.40	2,690,171	1.20	2,690,171	1.20
Shelley	10,384,108	10,455,358	0.69	10,454,587	0.68	10,450,734	0.64	10,441,294	0.55	10,441,294	0.55
Snake River	8,210,458	8,277,108	0.81	8,276,387	0.80	8,272,783	0.76	8,263,952	0.65	8,263,952	0.65
West Jefferson	3,097,371	3,143,340	1.48	3,142,830	1.47	3,140,446	1.39	3,134,317	1.19	3,134,317	1.19
Total ROI	172,547,942	175,646,429	1.80	175,607,056	1.77	175,445,876	1.68	175,032,085	1.44	175,032,085	1.44
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a; IN DOC 1991a; IN School 1992a.

**TABLE D.3-20A.—Changes in School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Idaho National Engineering Laboratory Region of Influence**

Jurisdiction		No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues						
Arco		3,029,757	3,072,967	1.43	3,108,217	2.59
Blackfoot		16,265,237	16,474,163	1.28	16,653,700	2.39
Bonneville		29,145,644	30,791,141	5.65	32,168,545	10.37
Idaho Falls		42,326,502	45,142,183	6.65	47,472,410	12.16
Jefferson		13,017,612	13,328,533	2.39	13,589,420	4.39
Pocatello		47,830,642	48,038,614	0.43	48,216,623	0.81
Ririe		2,566,733	2,590,619	0.93	2,609,362	1.66
Shelley		9,786,330	9,909,334	1.26	10,012,750	2.31
Snake River		8,459,527	8,510,265	0.6	8,551,307	1.08
West Jefferson		3,173,725	3,250,747	2.43	3,315,159	4.46
Total ROI Revenues		175,601,709	181,108,566	3.14	185,697,493	5.75
Expenditures						
Arco		2,990,995	3,088,824	3.27	3,172,348	6.06
Blackfoot		15,523,365	15,659,825	0.88	15,777,089	1.63
Bonneville		28,724,762	29,967,614	4.33	31,032,462	8.03
Idaho Falls		40,629,058	42,724,318	5.16	44,519,490	9.58
Jefferson		12,572,160	12,810,275	1.89	13,014,602	3.52
Pocatello		47,757,386	47,951,319	0.41	48,117,312	0.75
Ririe		2,658,277	2,713,610	2.08	2,761,092	3.87
Shelley		10,384,108	10,483,420	0.96	10,568,762	1.78
Snake River		8,210,458	8,303,359	1.13	8,383,192	2.1
West Jefferson		3,097,371	3,161,469	2.07	3,216,472	3.85
Total ROI Expenditures		172,547,942	176,864,034	2.5	180,562,821	4.65

Source: Census 1973a; Census 1977a; Census 1983a; DOB 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a; IN DOC 1991a; IN School 1992a.

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; IN Census 1991a; IN DOC 1991a; IN School 1992a.

TABLE D.3-21.—*Distribution of Employees by Place of Residence for Nevada Test Site, 1991*

County/City	Number of Employees	Total Site Employment (percent)
Clark County	6,270	81.7
Henderson	357	4.7
Las Vegas	5,352	69.7
North Las Vegas	505	6.6
Nye County	1,173	15.3
Total ROI County	7,443	97

Source: NTS 1991a:1.

TABLE D.3-22.—*Employment and Local Economy Statistics for Nevada Test Site Regional Economic Area, 1970-2020*

Regional Economic Area	1970	1980	1990	2005	2010	2020
Civilian labor force	125,772	250,392	402,960	511,330	542,466	553,345
Total employment	118,081	233,281	382,980	485,977	515,568	525,909
Unemployment rate (percent)	6.1	6.8	5	5	5	5
Personal income (thousand dollars)	1,433,059	5,431,787	14,753,586	22,346,743	24,809,815	28,415,457
Per capita income (dollars per person)	4,825	11,001	18,883	22,778	23,638	25,062

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; NT ESD 1991a.

TABLE D.3-23.—Changes in Total Employment, Unemployment Rate, and Per Capita Income
During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Tritium Supply Technologies
for Nevada Test Site Regional Economic Area

Regional Economic Area	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Total employment	485,977	494,261	1.7	493,868	1.62	498,474	2.57	495,832	2.03	480,295	1.2
Unemployment rate (percent)	5	3.9	NA	3.9	NA	3.9	NA	3.9	NA	4	NA
Per capita income (dollars per person)	22,778	23,013	1.03	23,017	1.05	22,975	0.86	22,999	0.97	22,679	1.05
Operation											
Total employment	515,568	518,362	0.54	518,302	0.53	518,061	0.48	517,442	0.36	517,442	0.36
Unemployment rate (percent)	5	4.7	NA	4.6	NA	4.6	NA	4.7	NA	4.7	NA
Per capita income (dollars per person)	23,638	23,713	0.32	23,712	0.31	23,707	0.29	23,694	0.24	23,694	0.24

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; Census 1990a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; NT ESD 1991d.

TABLE D.3-23A.—Changes in Total Employment, Unemployment Rate, and Per Capita Income
During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Nevada Test Site Regional Economic Area

Regional Economic Area	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Total employment	485,977	496,903	2.25	502,206	3.34
Unemployment rate (percent)	5	3.8	NA	3.9	NA
Per capita income (dollars per person)	22,778	23,022	1.07	22,948	0.75
Operation					
Total employment	515,568	517,667	0.41	521,711	1.19
Unemployment rate (percent)	5	4.7	NA	4.5	NA
Per capita income (dollars per person)	23,638	23,701	0.26	23,778	0.59

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; NT ESD 1991d.

TABLE D.3-24A.—Changes in Total Employment, Unemployment Rate, and Per Capita Income During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Tritium Supply Technologies and Recycling for Nevada Test Site Regional Economic Area

Regional Economic Area	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Total employment	485,977	495,457	1.95	495,064	1.87	499,670	2.82	497,028	2.27	481,491	1.45
Unemployment rate (percent)	5.0	3.9	NA	3.9	NA	3.9	NA	3.9	NA	3.8	NA
Per capita income (dollars per person)	22,778	23,002	0.98	23,006	1	22,963	0.81	22,988	0.92	22,721	1.24
Operation											
Total employment	515,568	521,095	1.07	521,035	1.06	520,795	1.01	520,176	0.89	520,176	0.89
Unemployment rate (percent)	5.0	4.3	NA	4.3	NA	4.4	NA	4.4	NA	4.4	NA
Per capita income (dollars per person)	23,638	23,767	0.55	23,766	0.54	23,761	0.52	23,749	0.47	23,749	0.47

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; NT ESD 1991d.

TABLE D.3-24A.—Changes in Total Employment, Unemployment Rate, and Per Capita Income During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Nevada Test Site Regional Economic Area

Regional Economic Area	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Total employment	485,977	498,090	2.49	503,402	3.59
Unemployment rate (percent)	5	3.8	NA	3.9	NA
Per capita income (dollars per person)	22,778	23,008	1.01	22,937	0.7
Operation					
Total employment	515,568	520,401	0.94	524,444	1.72
Unemployment rate (percent)	5	4.4	NA	4.3	NA
Per capita income (dollars per person)	23,638	23,755	0.49	23,808	0.72

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; NT ESD 1991d.

TABLE D.3-25.—Population for Nevada Test Site Region of Influence, 1970-2020

Jurisdiction	1970	1980	1990	2005	2010	2020
Clark County	273,288	463,087	741,459	930,909	996,551	1,077,272
Henderson	16,395	24,363	64,942	81,535	87,285	94,355
Las Vegas	125,787	164,674	258,295	324,292	347,159	375,279
North Las Vegas	36,216	42,739	47,707	59,897	64,120	69,314
Nye County	5,599	9,048	17,781	22,765	24,328	26,250
Total ROI	278,887	472,135	759,240	953,674	1,020,879	1,103,522

Source: Census 1973a; Census 1977a; Census 1983a; NT Census 1991a.

TABLE D.3-26.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies for Nevada Test Site Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Clark County	930,909	935,918	0.54	935,151	0.46	944,156	1.42	938,986	0.87	906,927	0.12
Henderson	81,535	81,824	0.35	81,780	0.3	82,298	0.94	82,000	0.57	79,423	0.1
Las Vegas	324,292	328,565	1.32	327,911	1.12	335,593	3.48	331,183	2.12	316,150	0.18
North Las Vegas	59,897	60,301	0.67	60,239	0.57	60,967	1.79	60,549	1.09	58,360	0.13
Nye County	22,765	23,703	4.12	23,560	3.49	25,246	10.9	24,278	0.66	22,263	0.43
Total ROI	953,674	959,621	0.62	958,711	0.53	969,402	1.65	963,264	0.1	929,190	0.12
Operation											
Clark County	996,551	997,935	0.14	997,890	0.13	997,712	0.12	997,255	0.07	997,255	0.07
Henderson	87,285	87,365	0.09	87,362	0.09	87,352	0.08	87,326	0.05	87,326	0.05
Las Vegas	347,159	348,340	0.34	348,302	0.33	348,150	0.29	347,760	0.17	347,760	0.17
North Las Vegas	64,120	64,232	0.17	64,228	0.17	64,214	0.15	64,177	0.09	64,177	0.09
Nye County	24,328	24,587	1.06	24,579	1.03	24,546	0.9	24,460	0.54	24,460	0.54
Total ROI	1,020,879	1,022,522	0.16	1,022,469	0.16	1,022,258	0.14	1,021,715	0.08	1,021,715	0.08

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; SNL 1995a; NT Census 1991a.

TABLE D.3-26A.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Nevada Test Site Region of Influence

Region of Influence		No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction						
Clark County		930,909	939,974	0.97	951,217	2.18
Henderson		81,535	82,086	0.68	82,704	1.43
Las Vegas		324,292	331,531	2.23	341,617	5.34
North Las Vegas		59,897	60,613	1.2	61,537	2.74
Nye County		22,765	24,304	6.76	26,568	16.7
Total ROI Construction		953,674	964,278	1.11	977,785	2.53
Operation						
Clark County		996,551	997,350	0.08	1,000,474	0.39
Henderson		87,285	87,333	0.06	87,510	0.26
Las Vegas		347,159	347,793	0.18	350,506	0.96
North Las Vegas		64,120	64,183	0.1	64,437	0.49
Nye County		24,328	24,462	0.55	25,063	3.02
Total ROI Operation		1,020,879	1,021,812	0.09	1,025,537	0.46

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; NT Census 1991a.

TABLE D.3-27.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies and Recycling for Nevada Test Site Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Changes (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Clark County	930,909	938,255	0.79	937,487	0.71	946,507	1.68	941,323	1.12	907,415	0.17
Henderson	81,535	81,958	0.52	81,914	0.46	82,433	1.1	82,134	0.73	79,455	0.14
Las Vegas	324,292	330,558	1.93	329,904	1.73	337,599	4.1	333,176	2.74	316,497	0.29
North Las Vegas	59,897	60,490	0.99	60,428	0.89	61,156	2.1	60,738	1.4	58,397	0.19
Nye County	22,765	24,141	6.04	23,997	5.41	25,686	12.83	24,716	8.57	22,332	0.74
Total ROI	953,674	962,396	0.91	961,484	0.82	972,193	1.94	966,039	1.3	929,747	0.18
Operation											
Clark County	996,551	999,957	0.34	999,912	0.34	999,735	0.32	999,277	0.27	999,277	0.27
Henderson	87,285	87,481	0.22	87,478	0.22	87,468	0.21	87,442	0.18	87,442	0.18
Las Vegas	347,159	350,065	0.84	350,027	0.83	349,875	0.78	349,484	0.67	349,484	0.67
North Las Vegas	64,120	64,395	0.43	64,392	0.42	64,377	0.4	64,340	0.34	64,340	0.34
Nye County	24,328	24,966	2.62	24,958	2.59	24,924	2.45	24,838	2.1	24,838	2.1
Total ROI	1,020,879	1,024,923	0.4	1,024,870	0.39	1,024,659	0.37	1,024,115	0.32	1,024,115	0.32

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; NT Census 1991a.

TABLE D.3-27A.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Nevada Test Site Region of Influence

Region of Influence	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Clark County	930,909	942,458	1.24	953,568	2.43
Henderson	81,535	82,233	0.86	82,839	1.6
Las Vegas	324,292	333,578	2.86	343,627	5.96
North Las Vegas	59,897	60,811	1.53	61,727	3.06
Nye County	22,765	24,746	8.7	27,000	18.6
Total ROI Construction	953,674	967,204	1.42	980,568	2.82
Operation					
Clark County	996,551	999,398	0.29	1,003,380	0.69
Henderson	87,285	87,452	0.19	87,678	0.45
Las Vegas	347,159	349,526	0.68	352,945	1.67
North Las Vegas	64,120	64,348	0.36	64,672	0.86
Nye County	24,328	24,841	2.11	25,607	5.26
Total ROI Operation	1,020,879	1,024,239	0.33	1,028,987	0.79

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; NT Census 1991a.

TABLE D.3-28.—Total Housing Units for Nevada Test Site Region of Influence, 1970-2020

Jurisdiction	1970	1980	1990	2005	2010	2020
Clark County	93,047	190,607	317,188	398,233	426,314	460,845
Henderson	4,915	8,889	25,400	31,890	34,139	36,904
Las Vegas	43,054	67,133	109,670	137,692	147,401	159,340
North Las Vegas	10,416	14,123	15,837	19,884	21,285	23,010
Nye County	2,098	4,292	8,073	10,336	11,045	11,918
Total ROI	95,145	194,899	325,261	408,569	437,359	472,763

Source: Census 1972a; Census 1973a; Census 1977a; Census 1982a; Census 1983a; NT Census 1991a.

TABLE D.3-29.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies for Nevada Test Site Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Clark County	398,233	400,137	0.48	399,846	0.41	403,270	1.26	401,304	0.77	387,924	0.1
Henderson	31,890	32,000	0.34	31,983	0.29	32,180	0.91	32,067	0.55	31,063	0.1
Las Vegas	137,692	139,317	1.18	139,068	1	141,989	3.12	140,312	1.9	134,209	0.16
North Las Vegas	19,884	20,037	0.77	20,014	0.65	20,291	2.05	20,132	1.25	19,377	0.15
Nye County	10,336	10,693	3.45	10,638	2.92	11,279	9.13	10,911	5.56	10,101	0.36
Total ROI	408,569	410,830	0.55	410,484	0.47	414,549	1.46	412,215	0.89	398,025	0.11
Operation											
Clark County	426,314	426,840	0.12	426,823	0.12	426,755	0.1	426,581	0.06	426,581	0.06
Henderson	34,139	34,169	0.09	34,168	0.09	34,164	0.07	34,154	0.05	34,154	0.05
Las Vegas	147,401	147,850	0.3	147,836	0.29	147,778	0.26	147,629	0.16	147,629	0.16
North Las Vegas	21,286	21,328	0.2	21,327	0.19	21,321	0.17	21,307	0.1	21,307	0.1
Nye County	11,046	11,144	0.89	11,141	0.86	11,128	0.75	11,096	0.45	11,096	0.45
Total ROI Operation	437,359	437,984	0.14	437,964	0.14	437,883	0.12	437,677	0.07	437,677	0.07

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; NT Census 1991a.

TABLE D.3-29A.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Nevada Test Site Region of Influence

Region of Influence	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Clark County	398,233	401,679	0.87	405,954	1.94
Henderson	31,890	32,099	0.66	32,334	1.39
Las Vegas	137,692	140,444	2	144,279	4.78
North Las Vegas	19,884	20,156	1.37	20,507	3.14
Nye County	10,336	10,921	5.66	11,782	13.99
Total ROI Construction	408,569	412,600	0.99	417,736	2.24
Operation					
Clark County	426,314	426,617	0.07	427,805	0.35
Henderson	34,139	34,157	0.05	34,224	0.25
Las Vegas	147,401	147,642	0.16	148,674	0.86
North Las Vegas	21,286	21,309	0.11	21,406	0.57
Nye County	11,046	11,096	0.46	11,325	2.53
Total ROI Operation	437,359	437,714	0.08	439,130	0.4

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; NT Census 1991a.

TABLE D.3-30.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies and Recycling for Nevada Test Site Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Clark County	398,233	401,026	0.7	400,734	0.63	404,163	1.49	402,192	0.99	388,109	0.15
Henderson	31,890	32,051	0.5	32,034	0.45	32,231	1.07	32,118	0.71	31,075	0.14
Las Vegas	137,692	140,074	1.73	139,826	1.55	142,751	3.67	141,070	2.45	134,341	0.26
North Las Vegas	19,884	20,109	1.13	20,086	1.02	20,362	2.41	20,203	1.61	19,391	0.22
Nye County	10,336	10,859	5.06	10,804	4.53	11,447	10.74	11,078	7.18	10,127	0.62
Total ROI	408,569	411,885	0.81	411,538	0.73	415,610	1.72	413,270	1.15	398,236	0.16
Operation											
Clark County	426,314	427,609	0.3	427,591	0.3	427,524	0.28	427,350	0.24	427,350	0.24
Henderson	34,139	34,213	0.22	34,212	0.22	34,208	0.2	34,198	0.18	34,198	0.18
Las Vegas	147,401	148,506	0.75	148,491	0.74	148,434	0.7	148,285	0.6	148,285	0.6
North Las Vegas	21,286	21,390	0.49	21,389	0.49	21,383	0.46	21,369	0.39	21,369	0.39
Nye County	11,046	11,288	2.2	11,285	2.17	11,272	2.05	11,239	1.76	11,239	1.76
Total ROI Operation	437,359	438,897	0.35	438,877	0.35	438,796	0.33	438,589	0.28	438,589	0.28

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; NT Census 1991a.

TABLE D.3-30A.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Nevada Test Site Region of Influence

Region of Influence	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Clark County	398,233	402,624	1.1	406,848	2.16
Henderson	31,890	32,155	0.83	32,386	1.55
Las Vegas	137,692	141,223	2.56	145,044	5.34
North Las Vegas	19,884	20,231	1.75	20,579	3.50
Nye County	10,336	11,089	7.29	11,946	15.58
Total ROI Construction	408,569	413,713	1.26	418,794	2.5
Operation					
Clark County	426,314	427,396	0.25	428,910	0.61
Henderson	34,139	34,202	0.19	34,288	0.44
Las Vegas	147,401	148,301	0.61	149,601	1.49
North Las Vegas	21,286	21,372	0.41	21,495	0.99
Nye County	11,046	11,241	1.77	11,532	4.4
Total ROI Operation	437,359	438,637	0.29	440,442	0.7

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; NT Census 1991a.

TABLE D.3-31.—County and City Revenues and Expenditures for Nevada Test Site Region of Influence 1992

Revenues and Expenditures	Clark County	Henderson	North	
			Las Vegas	Nye County
Ad valorem taxes and special assessment (percent)	25	21	22	18
Intergovernmental (percent)	39	51	51	66
Permits, fees, fines, and investment interest (percent)	34	24	24	10
Other	2	4	4	5
Total Revenues (dollars)	527,235,584	38,301,218	165,653,374	22,214,620
General Government (percent)	30	24	24	46
Public safety, health, and community service (percent)	48	43	51	36
Public works, parks, culture, and recreation (percent)	12	18	17	17
Debt service (percent)	10	15	7	1
Other (percent)	0	1	2	1
Total Expenditures (dollars)	440,571,167	37,804,113	156,464,143	19,819,986
End-of-Year Fund Balance (dollars)	292,589,218	11,785,009	52,674,187	9,504,516

Source: NT City 1992a; NT County 1992b.

TABLE D.3-32.—School District Revenues and Expenditures for Nevada Test Site Region of Influence, 1992

Revenues and Expenditures	Clark County School District	Nye County School District
Local sources (percent)	56	55
State sources (percent)	41	42
Federal sources (percent)	3	3
Total Revenues (dollars)	612,625,040	20,964,283
Total expenditures per pupil (dollars)	4,999	6,244
Instructional programs (percent)	59	52
School administration, services, and transportation (percent)	32	18
Maintenance, operation, and facilities acquisition (percent)	0	13
Debt service (percent)	9	17
Total Expenditures (dollars)	625,721,294	21,206,033
End-of-Year Fund Balance (dollars)	61,326,714	2,671,943

Source: NT School 1992a.

TABLE D.3-33.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies for Nevada Test Site Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Clark County	470,864,564	472,986,283	0.45	472,764,202	0.4	475,370,516	0.96	473,538,762	0.57	465,032,813	0.27
Henderson	36,172,899	36,265,990	0.26	36,251,736	0.22	36,419,094	0.68	36,250,130	0.21	35,725,782	0.07
Las Vegas	171,479,001	171,909,837	0.25	171,843,865	0.21	172,618,411	0.66	171,836,434	0.21	169,435,559	0.07
North Las Vegas	31,988,776	32,056,742	0.21	32,046,334	0.18	32,168,522	0.56	32,045,162	0.18	31,666,195	0.06
Nye County	20,643,251	21,063,855	2.04	21,013,375	1.79	21,608,293	4.67	21,114,202	2.28	20,611,648	1.02
Total ROI County and City Revenues	731,148,491	734,282,706	0.43	733,919,512	0.38	738,184,836	0.96	734,784,689	0.5	722,471,996	0.23
Clark County School District	574,221,722	577,311,451	0.54	576,838,335	0.46	582,392,977	1.42	576,785,046	0.45	559,646,031	0.15
Nye County School District	23,117,186	24,069,356	4.12	23,924,146	3.49	25,636,205	10.9	23,906,457	3.41	22,778,642	1.19
Total ROI School District Revenues	597,338,909	601,380,807	0.68	600,762,481	0.57	608,029,182	1.79	600,691,504	0.56	582,424,674	0.19
Expenditures											
Clark County	467,347,399	469,649,651	0.49	469,297,118	0.42	473,436,052	1.3	469,257,410	0.41	456,408,681	0.14
Henderson	39,472,155	39,651,393	0.45	39,623,947	0.38	39,946,177	1.2	39,620,855	0.38	38,628,457	0.13
Las Vegas	173,001,945	173,881,793	0.51	173,747,066	0.43	175,328,836	1.35	173,731,891	0.42	168,850,040	0.15
North Las Vegas	34,411,539	34,589,971	0.52	34,562,648	0.44	34,883,428	1.37	34,559,571	0.43	33,572,543	0.15
Nye County	21,325,240	22,186,044	4.04	22,054,768	3.42	23,602,546	10.68	22,038,776	3.35	21,021,570	1.16
Total ROI County and City Expenditures	735,558,279	739,958,852	0.6	739,285,547	0.51	747,197,038	1.58	739,208,504	0.5	718,481,291	0.17
Clark County School District	560,778,199	562,590,699	0.32	562,313,159	0.27	565,571,629	0.85	562,281,898	0.27	552,306,136	0.09
Nye County School District	21,718,565	22,476,933	3.49	22,361,279	2.96	23,724,872	9.24	22,347,190	2.89	21,450,051	1
Total ROI School District Expenditures	582,496,763	585,067,632	0.44	584,674,438	0.37	589,296,501	1.17	584,629,089	0.37	573,756,187	0.13

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; NT City 1992a; NT County 1992b; NT ESID 1991a; NT School 1992a.

TABLE D.3-33A.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Nevada Test Site Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Clark County	470,864,564	473,741,086	0.61	476,677,456	1.23
Henderson	36,172,899	36,255,973	0.23	36,414,140	0.67
Las Vegas	171,479,001	171,863,477	0.22	172,595,485	0.65
North Las Vegas	31,988,776	32,049,428	0.19	32,164,905	0.55
Nye County	20,643,251	21,149,833	2.45	21,775,830	5.49
Total ROI County and City Revenues	731,148,491	735,059,796	0.53	739,627,816	1.16
Clark County School District	574,221,722	576,978,982	0.48	582,228,558	1.39
Nye County School District	23,117,186	23,966,172	3.67	25,586,482	10.68
Total ROI School District Revenues	597,338,909	600,945,154	0.6	607,815,040	1.75
Expenditures					
Clark County	467,347,399	469,401,918	0.44	473,313,538	1.28
Henderson	39,472,155	39,632,106	0.41	39,936,638	1.18
Las Vegas	173,001,945	173,787,117	0.45	175,282,015	1.32
North Las Vegas	34,411,539	34,570,771	0.46	34,873,933	1.34
Nye County	21,325,240	22,092,761	3.6	23,557,594	10.47
Total ROI County and City Expenditures	735,558,279	739,484,673	0.53	746,963,719	1.55
Clark County School District	560,778,199	562,395,665	0.29	565,475,177	0.84
Nye County School District	21,718,565	22,394,751	3.11	23,685,270	9.06
Total ROI School District Expenditures	582,496,763	584,790,416	0.39	589,160,447	1.14

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; NT City 1992a; NT County 1992b; NT ESD 1991a; NT School 1992a.

**TABLE D.3-34.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies for Nevada Test Site Region of Influence**

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Clark County	489,301,418	489,944,322	0.13	489,927,120	0.13	489,858,145	0.11	489,681,265	0.08	489,681,265	0.08
Henderson	37,391,611	37,417,332	0.07	37,416,495	0.07	37,413,187	0.06	37,404,694	0.03	37,404,694	0.03
Las Vegas	177,124,019	177,243,056	0.07	177,239,185	0.07	177,223,875	0.06	177,184,567	0.03	177,184,567	0.03
North Las Vegas	32,880,105	32,898,883	0.06	32,898,273	0.06	32,895,858	0.05	32,889,657	0.03	32,889,657	0.03
Nye County	21,352,697	21,482,163	0.61	21,478,404	0.59	21,464,080	0.52	21,426,419	0.35	21,426,419	0.35
Total ROI	758,049,849	758,985,756	0.12	758,959,477	0.12	758,855,145	0.11	758,586,601	0.07	758,586,601	0.07
County and City Revenues											
Clark County School District	614,712,333	615,566,004	0.14	615,538,246	0.13	615,428,449	0.12	615,146,553	0.07	615,146,553	0.07
Nye County School District	24,704,043	24,967,019	1.06	24,958,896	1.03	24,925,386	0.9	24,838,056	0.54	24,838,056	0.54
Total ROI	639,416,375	640,533,023	0.17	640,497,142	0.17	640,353,834	0.15	639,984,609	0.09	639,984,609	0.09
Expenditures											
Clark County	497,476,660	498,112,757	0.13	498,092,074	0.12	498,010,260	0.11	497,800,211	0.07	497,800,211	0.07
Henderson	41,821,383	41,870,905	0.12	41,869,295	0.11	41,862,926	0.1	41,846,573	0.06	41,846,573	0.06
Las Vegas	184,529,136	184,772,232	0.13	184,764,327	0.13	184,733,061	0.11	184,652,786	0.07	184,652,786	0.07
North Las Vegas	36,749,765	36,799,065	0.13	36,797,462	0.13	36,791,121	0.11	36,774,841	0.07	36,774,841	0.07
Nye County	22,760,331	22,998,074	1.04	22,990,730	1.01	22,960,435	0.88	22,881,486	0.53	22,881,486	0.53
Total ROI	783,337,276	784,553,033	0.16	784,513,888	0.15	784,357,803	0.13	783,955,897	0.08	783,955,897	0.08
County and City Expenditures											
Clark County School District	584,491,173	584,991,954	0.09	584,975,671	0.08	584,911,261	0.07	584,745,895	0.04	584,745,895	0.04
Nye County School District	22,981,958	23,191,409	0.91	23,184,939	0.88	23,158,249	0.77	23,088,695	0.46	23,088,695	0.46
Total ROI	607,473,131	608,183,363	0.12	608,160,610	0.11	608,069,511	0.1	607,834,590	0.06	607,834,590	0.06
School District Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; NT City 1992a; NT County 1992b; NT ESD 1991a; NT School 1992a.

TABLE D.3-34A.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Nevada Test Site Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Clark County	489,301,418	489,840,270	0.11	491,334,951	0.42
Henderson	37,391,611	37,410,009	0.05	37,472,485	0.22
Las Vegas	177,124,019	177,209,165	0.05	177,498,310	0.21
North Las Vegas	32,880,105	32,893,537	0.04	32,939,151	0.18
Nye County	21,352,697	21,456,640	0.49	21,761,245	1.91
Total ROI County and City Revenues	758,049,849	758,809,620	0.1	761,006,141	0.39
Clark County School District	614,712,333	615,322,954	0.10	617,396,551	0.44
Nye County School District	24,704,043	24,891,277	0.76	25,532,315	3.35
Total ROI School District Revenues	639,416,375	640,214,232	0.12	642,928,866	0.55
Expenditures					
Clark County	497,476,660	497,931,654	0.09	499,476,754	0.4
Henderson	41,821,383	41,856,806	0.08	41,977,097	0.37
Las Vegas	184,529,136	184,703,019	0.09	185,293,508	0.41
North Las Vegas	36,749,765	36,785,029	0.1	36,904,778	0.42
Nye County	22,760,331	22,929,600	0.74	23,509,127	3.29
Total ROI County and City Expenditures	783,337,276	784,206,107	0.11	787,161,265	0.49
Clark County School District	584,491,173	584,849,376	0.06	586,065,792	0.27
Nye County School District	22,981,958	23,131,083	0.65	23,641,647	2.87
Total ROI School District Expenditures	607,473,131	607,980,460	0.08	609,707,439	0.37

Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; NT City 1992a; NT County 1992b; NT ESD 1991a; NT School 1992a.

TABLE D.3-35.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies and Recycling for Nevada Test Site Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Clark County	470,864,564	473,662,783	0.59	473,440,473	0.55	476,050,228	1.1	474,175,471	0.7	465,503,352	0.38
Henderson	36,172,899	36,309,424	0.38	36,295,150	0.34	36,462,787	0.8	36,278,565	0.29	35,741,049	0.12
Las Vegas	171,479,001	172,110,849	0.37	172,044,791	0.33	172,820,628	0.78	171,968,034	0.29	169,506,217	0.11
North Las Vegas	31,988,776	32,088,452	0.31	32,078,031	0.28	32,200,422	0.66	32,065,923	0.24	31,677,341	0.1
Nye County	20,643,251	21,218,340	2.79	21,167,550	2.54	21,763,399	5.43	21,241,022	2.9	20,697,574	1.44
Total ROI	731,148,491	735,389,848	0.58	735,025,996	0.53	739,297,463	1.11	735,729,015	0.63	723,125,533	0.32
County and City											
Revenues											
Clark County	574,221,722	578,753,006	0.79	578,279,273	0.71	583,843,168	1.68	577,728,815	0.61	560,152,757	0.25
School District											
Nye County	23,117,186	24,514,126	6.04	24,367,900	5.41	26,083,006	12.83	24,197,715	4.67	22,934,778	1.88
School District											
Total ROI	597,338,909	603,267,132	0.99	602,647,173	0.89	609,926,173	2.11	601,926,530	0.77	583,087,535	0.31
School District											
Revenues											
Expenditures											
Clark County	467,347,399	470,723,798	0.72	470,370,805	0.65	474,516,634	1.53	469,960,642	0.56	456,786,258	0.22
Henderson	39,472,155	39,735,019	0.67	39,707,537	0.60	40,030,303	1.41	39,675,604	0.52	38,657,852	0.21
Las Vegas	173,001,945	174,292,298	0.75	174,157,395	0.67	175,741,800	1.58	174,000,644	0.58	168,994,338	0.23
North Las Vegas	34,411,539	34,673,220	0.76	34,645,862	0.68	34,967,176	1.61	34,614,073	0.59	33,601,807	0.24
Nye County	21,325,240	22,588,136	5.92	22,455,941	5.3	24,006,473	12.57	22,302,087	4.58	21,162,723	1.84
Total ROI	735,558,279	742,012,471	0.88	741,337,541	0.79	749,262,387	1.86	740,553,050	0.68	719,202,978	0.27
County and City											
Expenditures											
Clark County	560,778,199	563,436,345	0.47	563,158,443	0.42	566,422,341	1.01	562,835,533	0.37	552,603,392	0.15
School District											
Nye County	21,718,565	22,831,176	5.12	22,714,713	4.59	24,080,732	10.88	22,579,167	3.96	21,574,407	1.59
School District											
Total ROI	582,496,763	586,267,521	0.65	585,873,156	0.58	590,503,073	1.37	585,414,700	0.5	574,177,799	0.2
School District											
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; NT City 1992a; NT County 1992b; NT ESD 1991a; NT School 1992a.

TABLE D.3-35A.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Nevada Test Site Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Clark County	470,864,564	474,373,659	0.75	478,386,218	1.6
Henderson	36,172,899	36,284,890	0.31	36,529,874	0.99
Las Vegas	171,479,001	171,997,307	0.3	173,131,108	0.96
North Las Vegas	31,988,776	32,070,540	0.26	32,249,401	0.81
Nye County	20,643,251	21,276,804	3.07	22,174,204	7.42
Total ROI County and City Revenues	731,148,491	736,003,201	0.66	742,470,806	1.55
Clark County School District	574,221,722	577,938,747	0.65	586,069,770	2.06
Nye County School District	23,117,186	24,262,395	4.95	26,769,271	15.8
Total ROI School District Revenues	597,338,909	602,201,142	0.81	612,839,041	2.59
Expenditures					
Clark County	467,347,399	470,117,068	0.59	476,175,744	1.89
Henderson	39,472,155	39,687,783	0.55	40,159,471	1.74
Las Vegas	173,001,945	174,060,425	0.61	176,375,859	1.95
North Las Vegas	34,411,539	34,626,197	0.62	35,095,762	1.99
Nye County	21,325,240	22,360,560	4.85	24,626,888	15.48
Total ROI County and City Expenditures	735,538,279	740,852,033	0.72	752,433,724	2.29
Clark County School District	560,778,199	562,958,684	0.39	567,728,513	1.24
Nye County School District	21,718,565	22,630,682	4.2	24,627,318	13.39
Total ROI School District Expenditures	582,496,763	585,589,365	0.53	592,355,831	1.69

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; NT City 1992a; NT County 1992b; NT ESD 1991a; NT School 1992a.

**TABLE D.3-36.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies and Recycling for Nevada Test Site Region of Influence**

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Clark County	489,301,418	490,726,614	0.29	490,709,287	0.29	490,640,791	0.27	490,463,557	0.24	490,463,557	0.24
Henderson	37,391,611	37,454,910	0.17	37,454,074	0.17	37,450,785	0.16	37,442,273	0.14	37,442,273	0.14
Las Vegas	177,124,019	177,416,974	0.17	177,413,103	0.16	177,397,879	0.15	177,358,485	0.13	177,358,485	0.13
North Las Vegas	32,880,105	32,926,320	0.14	32,925,709	0.14	32,923,307	0.13	32,917,093	0.11	32,917,093	0.11
Nye County	21,352,697	21,647,498	1.38	21,643,995	1.36	21,629,105	1.29	21,591,699	1.12	21,591,699	1.12
Total ROI	758,049,849	760,172,316	0.28	760,146,168	0.28	760,041,867	0.26	759,773,106	0.23	759,773,106	0.23
County and City Revenues											
Clark County School District	614,712,333	616,813,254	0.34	616,785,496	0.34	616,676,316	0.32	616,393,803	0.27	616,393,803	0.27
Nye County School District	24,704,043	25,351,877	2.62	25,343,753	2.59	25,309,228	2.45	25,221,899	2.1	25,221,899	2.1
Total ROI	639,416,375	642,165,131	0.43	642,129,250	0.42	641,985,543	0.4	641,615,702	0.34	641,615,702	0.34
Expenditures											
Clark County	497,476,660	499,042,121	0.31	499,021,438	0.31	498,940,084	0.29	498,729,576	0.25	498,729,576	0.25
Henderson	41,821,383	41,943,259	0.29	41,941,649	0.29	41,935,315	0.27	41,918,927	0.23	41,918,927	0.23
Las Vegas	184,529,136	185,127,405	0.32	185,119,501	0.32	185,088,410	0.3	185,007,960	0.26	185,007,960	0.26
North Las Vegas	36,749,765	36,871,093	0.33	36,869,490	0.33	36,863,185	0.31	36,846,870	0.26	36,846,870	0.26
Nye County	22,760,331	23,346,003	2.57	23,338,659	2.54	23,307,446	2.4	23,228,497	2.06	23,228,497	2.06
Total ROI	783,337,276	786,329,882	0.38	786,290,737	0.38	786,134,441	0.36	785,731,829	0.31	785,731,829	0.31
County and City Expenditures											
Clark County School District	584,491,173	585,723,617	0.21	585,707,334	0.21	585,643,286	0.2	585,477,559	0.17	585,477,559	0.17
Nye County School District	22,981,958	23,497,935	2.25	23,491,464	2.22	23,463,966	2.1	23,394,411	1.79	23,394,411	1.79
Total ROI	607,473,131	609,221,552	0.29	609,198,798	0.28	609,107,253	0.27	608,871,970	0.23	608,871,970	0.23
School District Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; NT City 1992a; NT County 1992b; NT ESD 1991a; NT School 1992a.

TABLE D.3-36A.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Nevada Test Site Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Clark County	489,301,418	491,353,489	0.42	492,990,035	0.75
Henderson	37,391,611	37,479,437	0.23	37,555,265	0.44
Las Vegas	177,124,019	177,530,485	0.23	177,881,421	0.43
North Las Vegas	32,880,105	32,944,226	0.2	32,999,587	0.36
Nye County	21,352,697	21,773,307	1.97	22,115,897	3.57
Total ROI County and City Revenues	758,049,849	761,080,944	0.4	763,542,204	0.72
Clark County School District	614,712,333	617,627,297	0.47	620,144,021	0.88
Nye County School District	24,704,043	25,603,763	3.64	26,380,085	6.78
Total ROI School District Revenues	639,416,375	643,231,060	0.6	646,524,106	1.11
Expenditures					
Clark County	497,476,660	499,648,690	0.44	501,523,978	0.81
Henderson	41,821,383	41,990,483	0.4	42,136,480	0.75
Las Vegas	184,529,136	185,359,216	0.45	186,075,892	0.84
North Las Vegas	36,749,765	36,918,104	0.46	37,063,444	0.85
Nye County	22,760,331	23,573,719	3.57	24,275,549	6.66
Total ROI County and City Expenditures	783,337,276	787,490,212	0.53	791,075,344	0.99
Clark County School District	584,491,173	586,201,152	0.29	620,144,021	0.55
Nye County School District	22,981,958	23,698,553	3.12	26,380,085	5.81
Total ROI School District Expenditures	607,473,131	609,899,705	0.4	646,524,106	0.74

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; NT City 1992a; NT County 1992b; NTESD 1991a; NT School 1992a.

TABLE D.3-37.—*Distribution of Employees by Place of Residence for Oak Ridge Reservation, 1990*

County/City	Number of Employees	Total Site Employment (percent)
Anderson County	5,053	33.1
Clinton	1,035	6.8
Oak Ridge	3,292	21.6
Knox County	5,490	36
Knoxville	4,835	31.7
Loudon County	848	5.6
Lenoir City	638	4.2
Roane County	2,537	16.6
Harriman	802	5.3
Kingston	1,033	6.8
Total ROI (County)	13,928	91.3

Source: ORR 1991a:4.

TABLE D.3-38.—*Employment and Local Economy Statistics for Oak Ridge Reservation Regional Economic Area, 1970-2020*

Regional Economic Area	1970	1980	1990	2005	2010	2020
Civilian labor force	349,630	460,364	525,461	597,924	611,220	602,822
Total employment	331,160	420,732	492,634	560,570	573,036	565,162
Unemployment rate (percent)	5.3	8.6	6.2	6.2	6.2	6.2
Personal income (thousand dollars)	2,461,301	7,971,913	16,196,884	23,562,265	25,332,874	28,160,468
Per capita income (dollars per person)	2,782	7,398	14,325	18,574	19,414	20,678

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; OR DES 1991a.

TABLE D.3-39.—Changes in Total Employment, Unemployment Rate, and Per Capita Income
During Peak Construction (2005 (2003 for Phased APT) and Full Operation (2010) from Tritium Supply Technologies
for Oak Ridge Reservation Regional Economic Area

Regional Economic Area	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Total employment	560,570	567,828	1.29	567,484	1.23	571,520	1.95	569,220	1.54	560,640	0.9
Unemployment rate (percent)	6.2	5.3	NA	5.3	NA	4.9	NA	5.1	NA	5.5	NA
Per capita income (dollars per person)	18,574	18,744	0.92	18,738	0.88	18,812	1.28	18,770	1.06	18,378	0.71
Operation											
Total employment	573,036	575,658	0.46	575,602	0.45	575,376	0.41	574,801	0.31	574,801	0.31
Unemployment rate (percent)	6.2	5.9	NA	5.9	NA	6	NA	6	NA	6	NA
Per capita income (dollars per person)	19,414	19,473	0.3	19,472	0.3	19,467	0.27	19,454	0.21	19,454	0.21

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; OR DES 1991a.

TABLE D.3-39A.—Changes in Total Employment, Unemployment Rate, and Per Capita Income During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Oak Ridge Reservation Regional Economic Area

Regional Economic Area	APT with Gas Power Plant			Triple Play MHTGR		
	No Action	Change (percent)	Change (percent)	Change (percent)	Change (percent)	Change (percent)
Construction						
Total employment	560,570	1.71	574,815	2.54		
Unemployment rate (percent)	6.2	NA	4.6	NA		
Per capita income (dollars per person)	18,574	1.17	18,873	1.61		
Operation						
Total employment	573,036	0.35	578,821	1.01		
Unemployment rate (percent)	6.2	NA	5.5	NA		
Per capita income (dollars per person)	19,414	0.23	19,545	0.68		

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; OR DES 1991a.

TABLE D.3-40.—Changes in Total Employment, Unemployment Rate, and Per Capita Income During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Tritium Supply Technologies and Recycling for Oak Ridge Reservation Regional Economic Area

Regional Economic Area	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Total employment	560,570	568,891	1.48	568,547	1.42	572,590	2.14	570,271	1.73	561,690	1.09
Unemployment rate (percent)	6.2	5.2	NA	5.2	NA	4.8	NA	5	NA	5.4	NA
Per capita income (dollars per person)	18,574	18,764	1.02	18,757	0.99	18,832	1.39	18,789	1.16	18,405	0.85
Operation											
Total employment	573,036	578,241	0.91	578,184	0.9	577,958	0.86	577,375	0.76	577,375	0.76
Unemployment rate (percent)	6.2	5.6	NA	5.6	NA	5.6	NA	5.7	NA	5.7	NA
Per capita income (dollars per person)	19,414	19,532	0.61	19,531	0.6	19,526	0.58	19,512	0.51	19,512	0.51

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995b; OR DES 1991a.

TABLE D.3-40A.—Changes in Total Employment, Unemployment Rate, and Per Capita Income
During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Oak Ridge Reservation Regional Economic Area

Regional Economic Area	No Action	APT with Gas Power Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Total employment	560,570	571,211	1.9	575,865	2.73
Unemploymentrate (percent)	6.2	4.9	NA	4.5	NA
Per capita income(dollars per person)	18,574	18,810	1.27	18,892	1.71
Operation					
Total employment	573,036	577,587	0.79	581,419	1.46
Unemploymentrate (percent)	6.2	5.7	NA	5.2	NA
Per capita income(dollars per person)	19,414	19,517	0.53	19,604	0.98

Note: NA - not applicable

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995b; OR DES 1991a.

TABLE D.3-41.—Population for Oak Ridge Reservation Region of Influence, 1970-2020

Jurisdiction	1970	1980	1990	2005	2010	2020
Anderson County	60,300	67,346	68,250	77,346	79,708	83,295
Clinton	4,794	5,245	8,972	10,168	10,478	10,950
Oak Ridge	28,319	27,662	27,310	30,950	31,895	33,330
Knox County	276,293	319,694	335,749	380,343	391,956	409,594
Knoxville	174,587	175,030	165,121	187,052	192,764	201,438
Loudon County	24,266	28,553	31,255	34,276	35,156	36,632
Lenoir City	5,324	5,446	6,147	6,741	6,914	7,205
Roane County	38,881	48,425	47,227	52,860	54,217	56,495
Harriman	8,734	8,303	7,119	7,968	8,173	8,516
Kingston	4,142	4,441	4,552	5,095	5,226	5,445
Total ROI (County)	399,740	464,018	482,481	544,825	561,037	586,016

Source: Census 1973a; Census 1977a; Census 1983a; OR Census 1991a.

TABLE D.3-42.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies for Oak Ridge Reservation Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Anderson County	77,346	78,370	1.32	78,280	1.21	79,341	2.58	78,731	1.79	76,644	0.29
Clinton	10,168	10,395	2.23	10,375	2.04	10,611	4.36	10,475	3.02	10,092	0.46
Oak Ridge	30,950	31,583	2.05	31,528	1.87	32,184	3.99	31,806	2.77	30,708	0.42
Knox County	380,343	381,447	0.29	381,350	0.26	382,493	0.57	381,836	0.39	376,188	0.1
Knoxville	187,052	188,024	0.52	187,938	0.47	188,945	1.01	188,366	0.7	185,085	0.15
Loudon County	34,276	34,448	0.5	34,433	0.46	34,611	0.98	34,509	0.68	33,979	0.14
Lenoir City	6,741	6,870	1.91	6,859	1.75	6,992	3.72	6,916	2.59	6,700	0.4
Roane County	52,860	53,368	0.96	53,323	0.88	53,849	1.87	53,547	1.3	52,446	0.23
Harriman	7,968	8,131	2.05	8,117	1.87	8,286	3.99	8,189	2.77	7,921	0.42
Kingston	5,095	5,298	3.98	5,280	3.63	5,490	7.75	5,369	5.38	5,082	0.76
Total ROI	544,825	547,633	0.52	547,386	0.47	550,294	1	548,623	0.7	539,257	0.15
Operation											
Anderson County	79,708	80,154	0.56	80,145	0.55	80,107	0.5	80,007	0.38	80,007	0.38
Clinton	10,478	10,577	0.94	10,575	0.92	10,567	0.85	10,545	0.64	10,545	0.64
Oak Ridge	31,895	32,171	0.87	32,165	0.85	32,142	0.77	32,080	0.58	32,080	0.58
Knox County	391,956	392,437	0.12	392,427	0.12	392,386	0.11	392,279	0.08	392,279	0.08
Knoxville	192,764	193,188	0.22	193,179	0.22	193,142	0.2	193,048	0.15	193,048	0.15
Loudon County	35,156	35,231	0.21	35,229	0.21	35,223	0.19	35,206	0.14	35,206	0.14
Lenoir City	6,914	6,970	0.81	6,969	0.79	6,964	0.72	6,952	0.55	6,952	0.55
Roane County	54,217	54,438	0.41	54,434	0.4	54,415	0.36	54,365	0.27	54,365	0.27
Harriman	8,173	8,244	0.87	8,243	0.86	8,236	0.77	8,221	0.59	8,221	0.59
Kingston	5,226	5,314	1.69	5,313	1.67	5,305	1.52	5,285	1.13	5,285	1.13
Total ROI	561,038	562,260	0.22	562,235	0.21	562,131	0.19	561,857	0.15	561,857	0.15

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; OR Census 1991a.

TABLE D.3-42A.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Oak Ridge Reservation Region of Influence

Region of Influence	APT with Gas Power			Change (percent)	Triple Play MHTGR	Change (percent)
	No Action	Plant				
Construction						
Anderson County	77,346	78,757		1.82	80,186	3.67
Clinton	10,168	10,478		3.05	10,799	6.21
Oak Ridge	30,950	31,816		2.8	32,707	5.68
Knox County	380,343	381,960		0.43	383,405	0.81
Knoxville	187,052	188,427		0.73	189,747	1.44
Loudon County	34,276	34,520		0.71	34,753	1.39
Lenoir City	6,741	6,918		2.62	7,099	5.31
Roane County	52,860	53,564		1.33	54,268	2.66
Harriman	7,968	8,192		2.81	8,420	5.67
Kingston	5,095	5,371		5.42	5,658	11.05
Total ROI Construction	544,825	548,801		0.73	552,612	1.43
Operation						
Anderson County	79,708	80,013		0.38	80,690	1.23
Clinton	10,478	10,546		0.65	10,696	2.08
Oak Ridge	31,895	32,082		0.59	32,502	1.9
Knox County	391,956	392,309		0.09	393,015	0.27
Knoxville	192,764	193,063		0.16	193,695	0.48
Loudon County	35,156	35,209		0.15	35,321	0.47
Lenoir City	6,914	6,953		0.56	7,038	1.79
Roane County	54,217	54,370		0.28	54,704	0.9
Harriman	8,173	8,221		0.59	8,329	1.91
Kingston	5,226	5,285		1.13	5,420	3.72
Total ROI Operation	561,038	561,901		0.15	563,730	0.48

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; OR Census 1991a.

TABLE D.3-43.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies and Recycling for Oak Ridge Reservation Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Anderson County	77,346	78,645	1.68	78,555	1.56	79,612	2.93	79,005	2.14	76,733	0.41
Clinton	10,168	10,456	2.83	10,436	2.64	10,671	4.95	10,536	3.62	10,112	0.66
Oak Ridge	30,950	31,753	2.59	31,698	2.42	32,352	4.53	31,976	3.32	30,764	0.6
Knox County	380,343	381,743	0.37	381,646	0.34	382,786	0.64	382,132	0.47	376,284	0.13
Knoxville	187,052	188,285	0.66	188,199	0.61	189,202	1.15	188,627	0.84	185,170	0.19
Loudon County	34,276	34,494	0.64	34,479	0.59	34,657	1.11	34,555	0.81	33,994	0.19
Lenoir City	6,741	6,905	2.43	6,893	2.25	7,027	4.24	6,950	3.1	6,711	0.57
Roane County	52,860	53,504	1.22	53,459	1.13	53,983	2.12	53,683	1.56	52,490	0.31
Harriman	7,968	8,175	2.6	8,161	2.42	8,329	4.53	8,232	3.31	7,935	0.6
Kingson	5,095	5,352	5.04	5,334	4.69	5,544	8.81	5,424	6.46	5,100	1.12
Total ROI	544,825	548,386	0.65	548,139	0.61	551,038	1.14	549,375	0.84	539,501	0.19
Operation											
Anderson County	79,708	80,591	1.11	80,582	1.1	80,544	1.05	80,445	0.92	80,445	0.92
Clinton	10,478	10,674	1.87	10,672	1.85	10,664	1.77	10,642	1.56	10,642	1.56
Oak Ridge	31,895	32,441	1.71	32,436	1.70	32,412	1.62	32,351	1.43	32,351	1.43
Knox County	391,956	392,908	0.24	392,898	0.24	392,857	0.23	392,750	0.2	392,750	0.2
Knoxville	192,764	193,602	0.43	193,593	0.43	193,557	0.41	193,463	0.36	193,463	0.36
Loudon County	35,156	35,305	0.42	35,303	0.42	35,297	0.4	35,280	0.35	35,280	0.35
Lenoir City	6,914	7,025	1.6	7,024	1.59	7,019	1.52	7,007	1.34	7,007	1.34
Roane County	54,217	54,655	0.81	54,650	0.8	54,631	0.76	54,582	0.67	54,582	0.67
Harriman	8,173	8,314	1.73	8,312	1.7	8,306	1.63	8,290	1.43	8,290	1.43
Kingson	5,226	5,401	3.35	5,399	3.31	5,392	3.18	5,372	2.8	5,372	2.8
Total ROI	561,038	563,459	0.43	563,433	0.43	563,329	0.41	563,057	0.36	563,057	0.36
Operation											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; OR Census 1991a.

TABLE D.3-43A.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Oak Ridge Reservation Region of Influence

Region of Influence	APT with Gas Power		Triple Play MHTGR	
	No Action	Plant	Change (percent)	Change (percent)
Construction				
Anderson County	77,346	79,032	2.18	4.03
Clinton	1,168	10,540	3.66	6.81
Oak Ridge	30,950	31,987	3.35	6.22
Knox County	380,343	382,264	0.51	0.88
Knoxville	187,052	188,692	0.88	1.58
Loudon County	34,276	34,567	0.85	1.53
Lenoir City	6,741	6,952	3.13	5.83
Roane County	52,860	53,702	1.59	2.92
Harriman	7,968	8,235	3.35	6.22
Kingston	5,095	5,426	6.5	12.11
Total ROI Construction	544,825	549,565	0.87	1.57
Operation				
Anderson County	79,708	80,451	0.93	1.8
Clinton	10,478	10,643	1.57	3.05
Oak Ridge	31,895	32,353	1.44	2.79
Knox County	391,956	392,781	0.21	0.4
Knoxville	192,764	193,478	0.37	0.71
Loudon County	35,156	35,283	0.36	0.69
Lenoir City	6,914	7,008	1.36	2.63
Roane County	54,217	54,587	0.68	1.31
Harriman	8,173	8,291	1.45	2.81
Kingston	5,226	5,372	2.8	5.46
Total ROI Operation	561,038	563,102	0.37	0.7

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; OR Census 1991a.

TABLE D.3-44. Total Housing Units for Oak Ridge Reservation Region of Influence, 1970-2020

Region of Influence	1970	1980	1990	2005	2010	2020
Anderson County	20,451	25,849	29,323	33,231	34,246	35,787
Clinton	1,702	2,073	4,006	4,540	4,678	4,889
Oak Ridge	9,972	11,487	12,694	15,878	16,363	17,099
Knox County	93,011	125,883	143,582	162,653	167,619	175,162
Knoxville	61,042	73,263	76,453	86,607	89,252	93,268
Loudon County	8,439	10,835	12,995	14,251	14,617	15,231
Lenoir City	1,982	2,342	2,734	2,998	3,075	3,205
Roane County	13,189	18,732	20,334	22,760	23,344	24,324
Harriman	3,132	3,355	3,234	3,620	3,173	3,869
Kingston	1,366	1,813	2,071	2,318	2,378	2,477
Total ROI (County)	135,090	181,299	206,234	232,895	239,826	250,504

Source: Census 1972a; Census 1973a; Census 1977a; Census 1982a; Census 1983a; OR Census 1991a.

TABLE D.3-45.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies for Oak Ridge Reservation Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Anderson County	33,231	33,620	1.17	33,586	1.07	33,990	2.28	33,758	1.58	32,918	0.26
Clinton	4,540	4,626	1.90	4,619	1.73	4,708	3.71	4,657	2.57	4,503	0.39
Oak Ridge	15,878	16,119	1.52	16,098	1.38	16,348	2.96	15,963	0.53	15,731	0.27
Knox County	162,653	163,072	0.26	163,035	0.24	163,470	0.50	163,220	0.35	160,857	0.09
Knoxville	86,607	86,977	0.43	86,944	0.39	87,327	0.83	87,107	0.58	85,674	0.12
Loudon County	14,251	14,316	0.46	14,311	0.42	14,378	0.89	14,340	0.62	14,126	0.13
Lenoir City	2,998	3,047	1.64	3,043	1.50	3,094	3.19	3,065	2.22	2,978	0.34
Roane County	22,760	22,953	0.85	22,935	0.77	23,135	1.65	23,021	1.15	22,575	0.20
Harriman	3,620	3,682	1.70	3,676	1.56	3,741	3.33	3,704	2.32	3,596	0.35
Kingston	2,318	2,395	3.33	2,388	3.04	2,468	6.48	2,422	4.49	2,309	0.64
Total ROI	232,895	233,962	0.46	233,868	0.42	234,973	0.89	234,338	0.62	230,476	0.13
Operation											
Anderson County	34,246	34,415	0.50	34,412	0.49	34,398	0.44	34,360	0.33	34,360	0.33
Clinton	4,679	4,716	0.80	4,715	0.79	4,712	0.72	4,704	0.54	4,704	0.54
Oak Ridge	16,363	16,468	0.46	16,466	0.63	16,457	0.57	16,434	0.43	16,434	0.43
Knox County	167,619	167,802	0.11	167,798	0.11	167,782	0.10	167,742	0.07	167,742	0.07
Knoxville	89,252	89,413	0.18	89,410	0.18	89,396	0.16	89,360	0.12	89,360	0.12
Loudon County	14,617	14,645	0.20	14,645	0.19	14,642	0.17	14,636	0.13	14,636	0.13
Lenoir City	3,075	3,096	0.69	3,096	0.68	3,094	0.62	3,090	0.47	3,090	0.47
Roane County	23,344	23,428	0.36	23,426	0.35	23,419	0.32	23,400	0.24	23,400	0.24
Harriman	3,713	3,740	0.73	3,739	0.72	3,737	0.65	3,731	0.49	3,731	0.49
Kingston	2,378	2,411	1.41	2,411	1.39	2,408	1.27	2,400	0.95	2,400	0.95
Total ROI	239,825	240,290	0.19	240,281	0.19	240,241	0.17	240,137	0.13	240,137	0.13

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; OR Census 1991a.

TABLE D.3-45A.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Oak Ridge Reservation Region of Influence

Region of Influence	APT with Gas Power				Change (percent)	Triple Play MHTGR	Change (percent)
	No Action	Plant					
Construction							
Anderson County	33,231	33,768			1.61	34,311	3.25
Clinton	4,540	4,658			2.60	4,780	5.29
Oak Ridge	13,219	13,548			2.49	13,887	5.05
Knox County	162,653	163,267			0.38	163,817	0.72
Knoxville	86,607	87,130			0.60	87,632	1.18
Loudon County	14,251	14,344			0.65	14,432	1.27
Lenoir City	2,998	3,066			2.24	3,134	4.54
Roane County	22,760	23,027			1.18	23,295	2.35
Harriman	3,620	3,705			2.35	3,792	4.75
Kingston	2,318	2,423			4.53	2,532	9.24
Total ROI Construction	232,895	234,406			0.65	235,855	1.27
Operation							
Anderson County	34,246	34,362			0.34	34,619	1.09
Clinton	4,679	4,704			0.55	4,761	1.77
Oak Ridge	13,622	13,693			0.52	13,853	1.69
Knox County	167,619	167,753			0.08	168,021	0.24
Knoxville	89,252	89,366			0.13	89,606	0.40
Loudon County	14,617	14,637			0.14	14,680	0.43
Lenoir City	3,075	3,090			0.48	3,122	1.53
Roane County	23,344	23,402			0.25	23,529	0.79
Harriman	3,713	3,731			0.49	3,772	1.60
Kingston	2,378	2,400			0.95	2,451	3.11
Total ROI Operation	239,825	240,154			0.14	240,849	0.43

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; OR Census 1991a.

**TABLE D.3-46.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies and Recycling for Oak Ridge Reservation Region of Influence**

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Anderson County	33,231	33,725	1.49	33,691	1.38	34,093	2.59	33,862	1.90	32,952	0.41
Clinton	4,540	4,650	2.41	4,642	2.24	4,731	4.21	4,680	3.08	4,511	0.66
Oak Ridge	15,878	16,184	1.92	16,163	1.79	16,411	3.36	15,997	0.75	15,752	0.41
Knox County	162,653	163,185	0.33	163,148	0.30	163,581	0.57	163,333	0.42	160,893	0.13
Knoxville	86,607	87,076	0.54	87,043	0.50	87,425	0.94	87,206	0.69	85,707	0.19
Loudon County	14,251	14,334	0.58	14,328	0.54	14,396	1.02	14,357	0.74	14,132	0.19
Lenoir City	2,998	3,061	2.09	3,056	1.93	3,107	3.63	3,078	2.65	2,982	0.57
Roane County	22,760	23,004	1.07	22,987	1.00	23,186	1.87	23,072	1.37	22,592	0.31
Harriman	3,620	3,698	2.17	3,693	2.02	3,757	3.78	3,720	2.77	3,601	0.60
Kingston	2,318	2,416	4.22	2,409	3.92	2,489	7.37	2,443	5.40	2,316	1.12
Total ROI	232,895	234,248	0.58	234,154	0.54	235,256	1.01	234,624	0.74	230,569	0.19
Operation											
Anderson County	34,246	34,582	0.98	34,578	0.97	34,564	0.93	34,526	0.82	34,526	0.82
Clinton	4,679	4,753	1.59	4,752	1.57	4,749	1.51	4,741	1.33	4,741	1.33
Oak Ridge	16,363	16,571	1.27	16,569	1.26	16,560	1.2	16,537	1.06	16,537	1.06
Knox County	167,619	167,981	0.22	167,977	0.21	167,961	0.2	167,921	0.18	167,921	0.18
Knoxville	89,252	89,571	0.36	89,567	0.35	89,554	0.34	89,518	0.3	89,518	0.3
Loudon County	14,617	14,674	0.39	14,673	0.38	14,671	0.37	14,664	0.32	14,664	0.32
Lenoir City	3,075	3,117	1.37	3,117	1.36	3,115	1.3	3,111	1.15	3,111	1.15
Roane County	23,344	23,510	0.71	23,508	0.7	23,501	0.67	23,482	0.59	23,482	0.59
Harriman	3,713	3,766	1.45	3,766	1.43	3,763	1.36	3,757	1.20	3,757	1.20
Kingston	2,378	2,444	2.80	2,443	2.77	2,441	2.66	2,433	2.34	2,433	2.34
Total ROI	239,825	240,746	0.38	240,736	0.38	240,697	0.36	240,593	0.32	240,593	0.32

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; OR Census 1991a.

TABLE D.3-46A.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Oak Ridge Reservation Region of Influence

Region of Influence	APT with Gas Power			Change (percent)	Triple Play MHTGR	Change (percent)
	No Action	Plant				
Construction						
Anderson County	33,231	33,872		1.93	34,415	3.56
Clinton	4,540	4,681		3.12	4,803	5.80
Oak Ridge	13,219	13,613		2.98	13,951	5.54
Knox County	162,653	163,383		0.45	163,929	0.78
Knoxville	86,607	87,231		0.72	87,731	1.30
Loudon County	14,251	14,362		0.78	14,450	1.40
Lenoir City	2,998	3,078		2.67	3,148	4.98
Roane County	22,760	23,080		1.41	23,346	2.58
Harriman	3,620	3,721		2.80	3,808	5.21
Kingston	2,318	2,444		5.43	2,553	10.12
Total ROI Construction	232,895	234,696		0.77	236,141	1.39
Operation						
Anderson County	34,246	34,528		0.82	34,793	1.60
Clinton	4,679	4,741		1.34	4,800	2.60
Oak Ridge	13,622	13,796		1.28	13,961	2.48
Knox County	167,619	167,932		0.19	168,208	0.35
Knoxville	89,252	89,524		0.30	89,771	0.58
Loudon County	14,617	14,665		0.33	14,709	0.63
Lenoir City	3,075	3,111		1.16	3,144	2.25
Roane County	23,344	23,484		0.60	23,615	1.16
Harriman	3,713	3,758		1.21	3,800	2.35
Kingston	2,378	2,433		2.34	2,486	4.56
Total ROI Operation	239,825	240,610		0.33	241,325	0.63

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; OR Census 1991a.

TABLE D.3-47.—County and City Revenues and Expenditures for Oak Ridge Reservation Region of Influence, 1992

Revenues and Expenditures	Anderson County	Clinton	Oak Ridge	Knox County	Knoxville	Loudon County	Lenoir City	Roane County	Harriman	Kingston
Property tax (percent)	39	61	22	29	70	45	32	44	18	52
Intergovernmental (percent)	48	20	66	33	17	47	56	45	74	24
Permits, fees, fines, and investment interest (percent)	12	10	11	13	3	7	9	11	5	4
Other (percent)	1	8	1	25	9	1	4	0	3	20
Total Revenues (dollars)	41,134,071	4,731,541	34,657,938	311,946,751	111,859,759	19,807,853	8,800,080	28,691,069	8,956,445	1,915,214
General government (percent)	21	27	3	5	5	22	11	20	10	28
Public safety, health, and community service (percent)	0	18	21	9	32	0	10	0	10	25
Public works, parks, culture, and recreation (public)	5	25	5	3	26	6	10	6	7	45
Debt service (percent)	8	19	6	5	26	13	7	6	4	2
Education (percent)	53	0	61	42	0	56	62	67	67	0
Other (percent)	13	12	4	36	12	2	0	1	3	0
Total Expenditures (dollars)	44,923,778	4,844,783	38,742,383	437,684,259	126,182,092	21,695,020	8,518,830	29,054,426	9,571,068	1,634,203
End-of-Year Fund Balance (dollars)	7,885,051	5,149,098	26,401,105	109,551,335	31,917,343	2,323,795	1,959,558	16,222,017	3,443,762	413,930

Source: OR City 1992a; OR County 1992a.

TABLE D.3-48.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies for Oak Ridge Reservation Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Anderson County	43,442,049	43,741,978	0.69	43,715,919	0.63	44,023,089	1.34	43,766,935	0.75	43,348,099	0.39
Clinton	5,036,437	5,083,775	0.94	5,079,668	0.86	5,128,076	1.82	5,087,822	1.02	5,021,892	0.57
Oak Ridge	39,066,506	39,551,576	1.24	39,509,274	1.13	40,007,924	2.41	39,589,199	1.34	38,942,320	0.75
Knox County	356,268,754	358,115,082	0.52	358,011,859	0.49	359,223,133	0.83	359,263,655	0.84	353,090,533	0.44
Knoxville	119,477,318	119,766,635	0.24	119,742,247	0.22	120,029,556	0.46	119,803,544	0.27	118,535,979	0.15
Loudon County	20,887,662	20,938,254	0.24	20,933,907	0.22	20,985,511	0.47	20,942,446	0.26	20,821,575	0.14
Lenoir City	9,006,611	9,025,235	0.21	9,023,620	0.19	9,042,793	0.40	9,026,516	0.22	8,979,874	0.12
Roane County	30,573,213	30,712,177	0.45	30,699,930	0.41	30,843,105	0.88	30,722,226	0.49	30,479,487	0.26
Harriman	9,003,994	9,020,993	0.19	9,019,491	0.17	9,037,051	0.37	9,022,155	0.20	8,992,869	0.11
Kingston	1,846,471	1,858,990	0.68	1,857,952	0.62	1,870,096	1.28	1,861,005	0.79	1,839,825	0.44
Total ROI County,	634,609,015	637,814,695	0.51	637,593,867	0.47	640,190,335	0.88	639,085,503	0.71	630,052,453	0.37
City, School District Revenues											
Expenditures											
Anderson County	46,106,174	46,378,827	0.59	46,354,856	0.54	46,637,445	1.15	46,396,602	0.63	45,992,281	0.33
Clinton	5,682,146	5,698,695	0.29	5,697,240	0.27	5,714,392	0.57	5,699,774	0.31	5,695,404	0.17
Oak Ridge	41,746,005	42,176,482	1.03	42,138,636	0.94	42,584,801	2.01	42,204,546	1.10	41,605,835	0.62
Knox County	485,281,724	486,544,702	0.26	486,433,729	0.24	487,741,372	0.51	486,627,526	0.28	480,847,408	0.15
Knoxville	125,439,503	125,622,129	0.15	125,606,082	0.13	125,795,167	0.28	125,634,105	0.16	124,714,075	0.09
Loudon County	22,480,305	22,527,668	0.21	22,523,541	0.19	22,572,515	0.41	22,530,610	0.22	22,415,688	0.12
Lenoir City	9,339,916	9,358,429	0.20	9,356,815	0.18	9,375,958	0.39	9,359,578	0.21	9,321,428	0.12
Roane County	30,397,924	30,533,497	0.45	30,521,476	0.41	30,661,990	0.87	30,542,075	0.47	30,322,410	0.25
Harriman	9,893,397	9,940,114	0.47	9,935,972	0.43	9,984,391	0.92	9,943,070	0.50	9,869,524	0.28
Kingston	1,809,609	1,822,245	0.70	1,821,125	0.64	1,834,222	1.36	1,823,045	0.74	1,804,509	0.42
Total ROI County,	778,176,702	780,602,788	0.31	780,389,473	0.28	782,902,254	0.61	780,760,932	0.33	772,588,562	0.18
City, School District Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; OR City 1992a; OR County 1992a; OR DES 1991a.

TABLE D.3-48A.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Oak Ridge Reservation Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Power Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Anderson County	43,442,049	43,791,515	0.80	44,280,091	1.93
Clinton	5,036,437	5,091,710	1.10	5,168,726	2.63
Oak Ridge	39,066,506	39,628,745	1.44	40,421,375	3.47
Knox County	356,268,754	359,490,243	0.90	361,602,656	1.50
Knoxville	119,477,318	119,828,226	0.29	120,288,002	0.68
Loudon County	20,887,662	20,946,591	0.28	21,029,171	0.68
Lenoir City	9,006,611	9,028,022	0.24	9,058,657	0.58
Roane County	30,573,213	30,733,500	0.52	30,960,966	1.27
Harriman	9,003,994	9,023,529	0.22	9,051,415	0.53
Kingston	1,846,471	1,862,104	0.85	1,881,602	1.90
Total ROI County, City, School District Revenues	634,609,015	639,424,185	0.76	643,742,660	1.44
Expenditures					
Anderson County	46,106,174	46,418,575	0.68	46,867,142	1.65
Clinton	5,682,146	5,701,108	0.33	5,728,334	0.81
Oak Ridge	41,746,005	42,239,238	1.18	42,947,456	2.88
Knox County	485,281,724	486,729,346	0.30	488,806,860	0.73
Knoxville	125,439,503	125,648,829	0.17	125,949,237	0.41
Loudon County	22,480,305	22,534,416	0.24	22,612,606	0.59
Lenoir City	9,339,916	9,361,066	0.23	9,391,629	0.55
Roane County	30,397,924	30,552,982	0.51	30,775,993	1.24
Harriman	9,893,397	9,946,828	0.54	10,023,675	1.32
Kingston	1,809,609	1,824,062	0.80	1,844,849	1.95
Total ROI County, City, School District Expenditures	778,176,702	780,956,449	0.36	784,947,781	0.87

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; SNL 1995a; OR City 1992a; OR County 1992a; OR DES 1991a.

**TABLE D.3-49.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies for Oak Ridge Reservation Region of Influence**

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Anderson County	44,120,170	44,250,377	0.30	44,247,747	0.29	44,236,650	0.26	44,207,092	0.20	44,207,092	0.20
Clinton	5,142,635	5,163,176	0.40	5,162,761	0.39	5,161,011	0.36	5,156,340	0.27	5,156,340	0.27
Oak Ridge	40,172,946	40,383,766	0.52	40,379,509	0.51	40,361,543	0.47	40,313,871	0.35	40,313,871	0.35
Knox County	368,580,846	369,300,475	0.20	369,285,137	0.19	369,223,339	0.17	369,061,881	0.13	369,061,881	0.13
Knoxville	122,273,105	122,397,015	0.10	122,394,432	0.10	122,383,854	0.09	122,355,833	0.07	122,355,833	0.07
Loudon County	21,139,450	21,161,458	0.10	21,160,877	0.10	21,159,117	0.09	21,154,108	0.07	21,154,108	0.07
Lenoir City	9,101,214	9,109,343	0.09	9,109,128	0.09	9,108,479	0.08	9,106,638	0.06	9,106,638	0.06
Roane County	30,936,687	30,996,962	0.19	30,995,866	0.19	30,990,674	0.17	30,976,945	0.13	30,976,945	0.13
Harriman	9,047,999	9,055,378	0.08	9,055,244	0.08	9,054,609	0.07	9,052,931	0.05	9,052,931	0.05
Kingston	1,876,300	1,881,627	0.28	1,881,527	0.28	1,881,070	0.25	1,879,799	0.19	1,879,799	0.19
Total ROI County, City, School District Revenues	652,391,351	653,699,577	0.20	653,672,227	0.20	653,560,345	0.18	653,265,440	0.13	653,265,440	0.13
Expenditures											
Anderson County	46,731,808	46,850,601	0.25	46,848,204	0.25	46,838,083	0.23	46,811,448	0.17	46,811,448	0.17
Clinton	5,726,309	5,733,519	0.13	5,733,373	0.12	5,732,759	0.11	5,731,142	0.08	5,731,142	0.08
Oak Ridge	42,737,749	42,925,305	0.44	42,921,520	0.43	42,905,540	0.39	42,863,489	0.29	42,863,489	0.29
Knox County	498,577,349	499,127,204	0.11	499,115,764	0.11	499,068,858	0.10	498,946,445	0.07	498,946,445	0.07
Knoxville	127,372,659	127,452,168	0.06	127,450,513	0.06	127,443,731	0.06	127,426,030	0.04	127,426,030	0.04
Loudon County	22,724,592	22,745,300	0.09	22,744,750	0.09	22,743,099	0.08	22,738,422	0.06	22,738,422	0.06
Lenoir City	9,434,520	9,442,614	0.09	9,442,399	0.08	9,441,753	0.08	9,439,925	0.06	9,439,925	0.06
Roane County	30,758,558	30,817,475	0.19	30,816,407	0.19	30,811,331	0.17	30,797,974	0.13	30,797,974	0.13
Harriman	10,017,982	10,038,283	0.20	10,037,915	0.20	10,036,166	0.18	10,031,564	0.14	10,031,564	0.14
Kingston	1,843,302	1,848,793	0.30	1,848,694	0.29	1,848,221	0.27	1,846,976	0.20	1,846,976	0.20
Total ROI County, City, School District Expenditures	795,924,827	796,981,262	0.13	796,959,539	0.13	796,869,542	0.12	796,633,416	0.09	796,633,416	0.09

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; OR City 1992a; OR County 1992a; OR DES 1991a.

TABLE D.3-49A.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Oak Ridge Reservation Region of Influence

	Jurisdiction	No Action (\$)	APT with Gas Power Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues						
Anderson County		44,120,170	44,245,190	0.28	44,534,797	0.94
Clinton		5,142,635	5,162,358	0.38	5,208,046	1.27
Oak Ridge		40,172,946	40,375,371	0.50	40,844,275	1.67
Knox County		368,580,846	369,269,521	0.19	370,869,791	0.62
Knoxville		122,273,105	122,391,518	0.10	122,667,417	0.32
Loudon County		21,139,450	21,160,688	0.10	21,209,086	0.33
Lenoir City		9,101,214	9,109,059	0.09	9,126,934	0.28
Roane County		30,936,687	30,994,366	0.19	31,129,017	0.62
Harriman		9,047,999	9,055,061	0.08	9,071,547	0.26
Kingston		1,876,300	1,881,399	0.27	1,893,289	0.91
Total ROI County, City, School District Revenues		652,391,351	653,644,531	0.19	656,554,200	0.64
Expenditures						
Anderson County		46,731,808	46,845,875	0.24	47,110,093	0.81
Clinton		5,726,309	5,733,232	0.12	5,749,269	0.40
Oak Ridge		42,737,749	42,917,843	0.42	43,335,004	1.40
Knox County		498,577,349	499,102,744	0.11	500,327,198	0.35
Knoxville		127,372,659	127,448,631	0.06	127,625,686	0.20
Loudon County		22,724,592	22,744,578	0.09	22,790,104	0.29
Lenoir City		9,434,520	9,442,332	0.08	9,460,127	0.27
Roane County		30,758,558	30,814,937	0.18	30,946,566	0.61
Harriman		10,017,982	10,037,409	0.19	10,082,766	0.65
Kingston		1,843,302	1,848,557	0.29	1,860,826	0.95
Total ROI County, City, School District Expenditures		795,924,827	796,936,136	0.13	799,287,639	0.42

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; OR City 1992a; OR County 1992a; OR DES 1991a.

TABLE D.3-50.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies and Recycling for Oak Ridge Reservation Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Anderson County	43,442,049	43,821,602	0.87	43,795,548	0.81	44,101,577	1.52	43,866,293	0.98	43,402,878	0.52
Clinton	5,036,437	5,096,324	1.19	5,092,218	1.11	5,140,446	2.07	5,103,499	1.33	5,030,313	0.74
Oak Ridge	39,066,506	39,680,830	1.57	39,638,534	1.46	40,135,323	2.74	39,750,029	1.75	39,027,974	0.97
Knox County	356,268,754	358,431,164	0.61	358,328,028	0.58	359,539,056	0.92	359,824,054	1.00	353,594,722	0.58
Knoxville	119,477,318	119,841,109	0.30	119,816,722	0.28	120,103,343	0.52	119,898,533	0.35	118,589,521	0.20
Loudon County	20,887,662	20,951,595	0.31	20,947,248	0.29	20,998,852	0.53	20,959,715	0.34	20,830,843	0.18
Lenoir City	9,006,611	9,030,191	0.26	9,028,575	0.24	9,047,749	0.46	9,032,889	0.29	8,983,147	0.16
Roane County	30,573,213	30,749,201	0.58	30,736,952	0.54	30,879,588	1.00	30,768,433	0.64	30,504,540	0.34
Harriman	9,003,994	9,025,534	0.24	9,024,031	0.22	9,041,526	0.42	9,027,811	0.26	8,995,836	0.15
Kingston	1,846,471	1,862,135	0.85	1,861,095	0.79	1,873,198	1.45	1,865,112	1.01	1,842,202	0.57
Total ROI County, City, School District Revenues	634,609,015	638,489,685	0.61	638,268,952	0.58	640,860,658	0.99	640,096,366	0.86	630,801,976	0.49
Expenditures											
Anderson County	46,106,174	46,452,071	0.75	46,428,100	0.70	46,709,624	1.31	46,487,175	0.83	46,041,245	0.44
Clinton	5,682,146	5,703,141	0.37	5,701,686	0.34	5,718,773	0.64	5,705,271	0.41	5,698,292	0.22
Oak Ridge	41,746,005	42,292,123	1.31	42,254,277	1.22	42,698,760	2.28	42,347,546	1.44	41,680,967	0.80
Knox County	485,281,724	486,883,339	0.33	486,772,366	0.31	488,076,577	0.58	487,045,844	0.36	481,074,534	0.19
Knoxville	125,439,503	125,671,096	0.18	125,655,049	0.17	125,843,638	0.32	125,694,594	0.20	124,746,003	0.11
Loudon County	22,480,305	22,540,324	0.27	22,536,197	0.25	22,585,171	0.47	22,546,835	0.30	22,424,199	0.16
Lenoir City	9,339,916	9,363,376	0.25	9,361,762	0.23	9,380,905	0.44	9,365,920	0.28	9,324,661	0.15
Roane County	30,397,924	30,569,828	0.57	30,557,806	0.53	30,697,786	0.99	30,587,216	0.62	30,346,642	0.33
Harriman	9,893,397	9,952,633	0.60	9,948,491	0.56	9,996,726	1.04	9,958,625	0.66	9,877,638	0.36
Kingston	1,809,609	1,825,632	0.89	1,824,511	0.82	1,837,559	1.54	1,827,253	0.98	1,806,704	0.54
Total ROI County, City, School District Expenditures	778,176,702	781,253,562	0.40	781,040,247	0.37	783,545,519	0.69	781,566,278	0.44	773,020,885	0.23

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; OR City 1992a; OR County 1992a; OR DES 1991a.

TABLE D.3-50A.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Oak Ridge Reservation Region of Influence

Jurisdiction	APT with Gas/Power			Change (percent)	Triple Play MHTGR	Change (percent)
	No Action (\$)	Plant				
Revenues						
Anderson County	43,442,049	43,891,688		1.04	44,474,266	2.38
Clinton	5,036,437	5,107,513		1.41	5,199,317	3.23
Oak Ridge	39,066,506	39,790,944		1.85	40,736,828	4.28
Knox County	356,268,754	360,036,871		1.06	362,281,835	1.69
Knoxville	119,477,318	119,923,746		0.37	120,468,377	0.83
Loudon County	20,887,662	20,964,028		0.37	21,061,652	0.83
Lenoir City	9,006,611	9,034,462		0.31	9,070,746	0.71
Roane County	30,573,213	30,780,118		0.68	31,051,331	1.56
Harriman	9,003,994	9,029,236		0.28	9,062,504	0.65
Kingston	1,846,471	1,866,227		1.07	1,889,173	2.31
Total ROI County, City, School District Revenues	634,609,015	640,424,834		0.92	645,296,031	1.68
Expenditures						
Anderson County	46,106,174	46,509,981		0.88	47,046,199	2.04
Clinton	5,682,146	5,706,656		0.43	5,739,202	1.00
Oak Ridge	41,746,005	42,383,554		1.53	43,230,160	3.56
Knox County	485,281,724	487,151,442		0.39	489,634,399	0.90
Knoxville	125,439,503	125,709,864		0.22	126,068,899	0.50
Loudon County	22,480,305	22,550,817		0.31	22,643,510	0.73
Lenoir City	9,339,916	9,367,477		0.30	9,403,709	0.68
Roane County	30,397,924	30,598,547		0.66	30,864,781	1.54
Harriman	9,893,397	9,962,529		0.70	10,054,270	1.63
Kingston	1,809,609	1,828,309		1.03	1,853,125	2.40
Total ROI County, City, School District Expenditures	778,176,702	781,769,175		0.46	786,538,254	1.07

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; OR City 1992a; OR County 1992a; OR DES 1991a.

TABLE D.3-51.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010) from Tritium Supply Technologies and Recycling for Oak Ridge Reservation Region of Influence

Region of Influence	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Anderson County	44,120,170	44,377,960	0.58	44,375,329	0.58	44,364,232	0.55	44,335,330	0.49	44,335,330	0.49
Clinton	5,142,635	5,183,304	0.79	5,182,889	0.78	5,181,138	0.75	5,176,578	0.66	5,176,578	0.66
Oak Ridge	40,172,946	40,590,332	1.04	40,586,075	1.03	40,568,109	0.98	40,521,314	0.87	40,521,314	0.87
Knox County	368,580,846	370,006,998	0.39	369,991,635	0.38	369,929,774	0.37	369,769,912	0.32	369,769,912	0.32
Knoxville	122,273,105	122,518,495	0.20	122,515,912	0.20	122,505,334	0.19	122,477,747	0.17	122,477,747	0.17
Loudon County	21,139,450	21,183,096	0.21	21,182,515	0.20	21,180,756	0.20	21,175,787	0.17	21,175,787	0.17
Lenoir City	9,101,214	9,117,336	0.18	9,117,121	0.17	9,116,472	0.17	9,114,636	0.15	9,114,636	0.15
Roane County	30,936,687	31,056,264	0.39	31,054,900	0.38	31,049,706	0.37	31,036,315	0.32	31,036,315	0.32
Harriman	9,047,999	9,062,639	0.16	9,062,472	0.16	9,061,836	0.15	9,060,197	0.13	9,060,197	0.13
Kingston	1,876,300	1,886,867	0.56	1,886,748	0.56	1,886,288	0.53	1,885,104	0.47	1,885,104	0.47
Total ROI County, City, School District Revenues	652,391,351	654,983,292	0.40	654,955,595	0.39	654,843,647	0.38	654,552,920	0.33	654,552,920	0.33
Expenditures											
Anderson County	46,731,808	46,966,992	0.50	46,964,595	0.50	46,954,474	0.48	46,928,106	0.42	46,928,106	0.42
Clinton	5,726,309	5,740,583	0.25	5,740,438	0.25	5,739,824	0.24	5,738,223	0.21	5,738,223	0.21
Oak Ridge	42,737,749	43,109,069	0.87	43,105,284	0.86	43,089,305	0.82	43,047,674	0.73	43,047,674	0.73
Knox County	498,577,349	499,666,049	0.22	499,654,609	0.22	499,607,703	0.21	499,485,290	0.18	499,485,290	0.18
Knoxville	127,372,659	127,530,084	0.12	127,528,430	0.12	127,521,648	0.12	127,503,947	0.10	127,503,947	0.10
Loudon County	22,724,592	22,765,660	0.18	22,765,110	0.18	22,763,459	0.17	22,758,782	0.15	22,758,782	0.15
Lenoir City	9,434,520	9,450,572	0.17	9,450,357	0.17	9,449,712	0.16	9,447,883	0.14	9,447,883	0.14
Roane County	30,758,558	30,875,444	0.38	30,874,108	0.38	30,869,033	0.36	30,855,943	0.32	30,855,943	0.32
Harriman	10,017,982	10,058,259	0.40	10,057,798	0.40	10,056,049	0.38	10,051,539	0.33	10,051,539	0.33
Kingston	1,843,302	1,854,197	0.59	1,854,072	0.58	1,853,599	0.56	1,852,379	0.49	1,852,379	0.49
Total ROI County, City, School District Expenditures	795,924,827	798,016,910	0.26	797,994,802	0.26	797,904,805	0.25	797,669,766	0.22	797,669,766	0.22

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; OR City 1992a; OR County 1992a; OR DES 1991a.

TABLE D.3-51A.—Changes in County, City, and School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Oak Ridge Reservation Region of Influence

Region of Influence	APT with Gas Power			Triple Play MHTGR	Change (percent)	Change (percent)
	No Action (\$)	Plant				
Revenues						
Anderson County	44,120,170	44,508,202		44,788,689	0.88	1.52
Clinton	5,142,635	5,203,851		5,248,101	1.19	2.05
Oak Ridge	40,172,946	40,801,209		41,255,344	1.56	2.69
Knox County	368,580,846	370,725,577		372,277,113	0.58	1.00
Knoxville	122,273,105	122,642,423		122,909,260	0.30	0.52
Loudon County	21,139,450	21,204,702		21,252,280	0.31	0.53
Lenoir City	9,101,214	9,125,314		9,142,890	0.26	0.46
Roane County	30,936,687	31,116,065		31,246,404	0.58	1.00
Harriman	9,047,999	9,069,960		9,085,919	0.24	0.42
Kingston	1,876,300	1,892,158		1,903,673	0.85	1.46
Total ROI County, City, School District Revenues	652,391,351	656,289,461		659,109,672	0.60	1.03
Expenditures						
Anderson County	46,731,808	47,085,817		47,341,710	0.76	1.31
Clinton	5,726,309	5,747,796		5,763,327	0.38	0.65
Oak Ridge	42,737,749	43,296,675		43,700,691	1.31	2.25
Knox County	498,577,349	500,216,007		501,399,769	0.33	0.57
Knoxville	127,372,659	127,609,608		127,780,780	0.19	0.32
Loudon County	22,724,592	22,785,978		22,830,748	0.27	0.47
Lenoir City	9,434,520	9,458,514		9,476,014	0.25	0.44
Roane County	30,758,558	30,933,892		31,061,299	0.57	0.98
Harriman	10,017,982	10,078,399		10,122,302	0.60	1.04
Kingston	1,843,302	1,859,645		1,871,520	0.89	1.53
Total ROI County, City, School District Expenditures	795,924,827	799,072,330		801,348,161	0.40	0.68

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; OR City 1992a; OR County 1992a; OR DES 1991a.

TABLE D.3-52.—*Distribution of Employees by Place of Residence for Pantex Plant, 1991*

County/City	Number of Employees	Total Site Employment (percent)
Carson County	143	5.5
Potter/Randall Counties	2,203	84.9
Amarillo ^a	2,145	82.7
Total ROI (County)	2,346	90.4

^a Amarillo is located in Potter County and Randall County.

Source: PX 1991a:5.

TABLE D.3-53.—*Employment and Local Economy Statistics for Pantex Plant Regional Economic Area, 1970-2020*

Regional Economic Area	1970	1980	1990	2005	2010	2020
Civilian labor force	110,508	138,326	158,111	174,336	176,176	169,690
Total employment	106,774	132,545	150,911	166,398	168,153	161,962
Unemployment rate (percent)	3.4	4.2	4.6	4.6	4.6	4.6
Personal income (thousand dollars)	1,105,838	2,956,763	5,485,191	7,569,413	7,980,631	8,620,287
Per capita income (dollars per person)	4,091	9,625	17,546	23,127	24,200	25,703

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; PX DOC 1991a.

TABLE D.3-54.—Changes in Total Employment, Unemployment Rate, and Per Capita Income
During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Tritium Supply Technologies
for Pantex Plant Regional Economic Area

Regional Economic Area	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Total employment	166,398	173,008	3.97	172,694	3.78	176,370	5.99	174,261	4.73	170,226	2.73
Unemployment rate (percent)	4.6	2.2	NA	2.3	NA	2.2	NA	2.2	NA	2.5	NA
Per capita income (dollars per person)	23,127	23,535	1.76	23,529	1.74	23,378	1.09	23,475	1.51	23,126	1.83
Operation											
Total employment	168,153	170,842	1.60	170,784	1.56	170,553	1.43	169,957	1.07	169,957	1.07
Unemployment rate (percent)	4.6	3.4	NA	3.6	NA	3.9	NA	3.8	NA	3.8	NA
Per capita income (dollars per person)	24,200	24,436	0.98	24,431	0.95	24,410	0.69	24,358	0.65	24,358	0.65

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX DOC 1991a.

TABLE D.3-54A.—Changes in Total Employment, Unemployment Rate, and Per Capita Income
During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Regional Economic Area

Regional Economic Area	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Total employment	166,398	175,116	5.24	179,347	7.78
Unemployment rate (percent)	4.6	2	NA	2.2	NA
Per capita income (dollars per person)	23,127	23,512	1.66	23,238	0.48
Operation					
Total employment	168,153	170,174	1.2	174,066	3.52
Unemployment rate (percent)	4.6	3.7	NA	2.9	NA
Per capita income (dollars per person)	24,200	24,377	0.73	24,622	1.74

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX DOC 1991a.

TABLE D.3-55.—Changes in Total Employment, Unemployment Rate, and Per Capita Income During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Tritium Supply Technologies and Recycling for Pantex Plant Regional Economic Area

Regional Economic Area	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Total employment	166,398	173,962	4.55	173,649	4.36	177,324	6.57	175,216	5.3	171,182	3.31
Unemployment rate (percent)	4.6	2.2	NA	2.2	NA	2.2	NA	2.2	NA	2.3	NA
Per capita income (dollars per person)	23,127	23,490	1.56	23,504	1.63	23,325	0.86	23,431	1.31	23,126	1.83
Operation											
Total employment	168,153	173,473	3.16	173,416	3.13	173,184	2.99	172,589	2.64	172,589	2.64
Unemployment rate (percent)	4.6	2.5	NA	2.5	NA	2.7	NA	2.8	NA	2.8	NA
Per capita income (dollars per person)	24,200	24,594	1.62	24,591	1.62	24,555	1.47	24,546	1.43	24,546	1.43

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; PX DOC 1991a.

TABLE D.3-55A.—Changes in Total Employment, Unemployment Rate, and Per Capita Income During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Regional Economic Area

Regional Economic Area	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Total employment	166,398	176,071	5.81	180,302	8.36
Unemployment rate (percent)	4.6	2.0	NA	2.2	NA
Per capita income (dollars per person)	23,127	23,460	1.44	23,196	0.3
Operation					
Total employment	168,153	172,806	2.77	176,726	5.1
Unemployment rate (percent)	4.6	2.7	NA	2.4	NA
Per capita income (dollars per person)	24,200	24,563	1.48	24,564	1.5

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; PX DOC 1991a.

TABLE D.3-56.—Population for Pantex Plant Region of Influence, 1970-2020

Jurisdiction	1970	1980	1990	2005	2010	2020
Carson County	6,358	6,672	6,576	6,766	6,793	6,888
Potter County	90,511	98,637	97,874	104,820	105,863	107,875
Amarillo	127,010	149,230	157,615	165,050	166,692	169,859
Randall County	53,885	75,062	89,673	91,573	92,485	94,242
ROI Total	150,754	180,371	194,123	203,159	205,141	209,005

Source: Census 1973a; Census 1977a; Census 1983a; PX Census 1991a.

TABLE D.3-57.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies for Pantex Plant Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Carson County	6,766	7,041	4.06	7,016	3.7	7,493	10.74	7,209	6.56	6,809	0.8
Potter County	104,820	107,327	2.39	107,096	2.17	111,453	6.33	108,845	3.84	104,972	0.54
Amarillo	165,050	169,183	2.5	168,802	2.27	175,983	6.62	171,719	4.04	165,319	0.56
Randall County	91,573	93,308	1.89	93,148	1.72	96,162	5.01	94,395	3.08	91,633	0.46
Total ROI	203,159	207,676	2.22	207,260	2.02	215,108	5.88	210,449	3.59	203,414	0.51
Operation											
Carson County	6,793	6,866	1.08	6,865	1.07	6,858	0.96	6,842	0.73	6,842	0.73
Potter County	105,863	106,530	0.63	106,516	0.62	106,459	0.56	106,311	0.42	106,311	0.42
Amarillo	166,692	167,792	0.66	167,768	0.65	167,674	0.59	167,430	0.44	167,430	0.44
Randall County	92,485	92,947	0.5	92,937	0.49	92,897	0.45	92,795	0.34	92,795	0.34
Total ROI Operation	205,141	206,343	0.59	206,318	0.57	206,214	0.52	205,948	0.39	205,948	0.39

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX Census 1991a.

TABLE D.3-57A.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Region of Influence

Region of Influence	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Carson County	6,766	7,226	6.81	7,891	16.64
Potter County	104,820	105,068	0.24	115,029	9.74
Amarillo	165,050	165,441	0.24	181,968	10.25
Randall County	91,573	99,097	8.22	98,730	7.82
Total ROI Construction	203,159	211,391	4.05	221,650	9.1
Operation					
Carson County	6,793	6,844	0.76	7,029	3.48
Potter County	105,863	105,894	0.03	108,009	2.03
Amarillo	166,692	166,741	0.03	170,248	2.13
Randall County	92,485	93,319	0.9	93,989	1.63
Total ROI Operation	205,141	206,057	0.45	209,027	1.89

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX Census 1991a.

TABLE D.3-58.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies and Recycling for Pantex Plant Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Carson County	6,766	7,169	5.96	7,127	5.34	7,621	12.64	7,337	8.45	6,870	1.71
Potter County	104,820	108,498	3.51	108,114	3.14	112,624	7.45	110,009	4.95	105,625	1.17
Amarillo	165,050	171,112	3.67	170,479	3.29	177,913	7.79	173,649	5.21	166,377	1.2
Randall County	91,573	94,118	2.78	93,852	2.49	96,972	5.90	95,211	3.97	92,129	1.01
Total ROI	203,159	209,785	3.26	209,093	2.92	217,217	6.92	212,557	4.63	204,624	1.11
Operation											
Carson County	6,793	6,996	3	6,993	2.95	6,980	2.76	6,943	2.22	6,943	2.22
Potter County	105,863	107,713	1.75	107,684	1.72	107,569	1.61	107,274	1.33	107,274	1.33
Amarillo	166,692	169,741	1.83	169,694	1.8	169,504	1.69	169,017	1.39	169,017	1.39
Randall County	92,485	93,765	1.38	93,745	1.36	93,665	1.28	93,461	1.06	93,461	1.06
Total ROI Operation	205,141	208,474	1.62	208,422	1.6	208,214	1.5	207,678	1.24	207,678	1.24

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; PX Census 1991a.

TABLE D.3-58A.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Region of Influence

Region of Influence	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Carson County	6,766	7,357	8.74	8,019	18.53
Potter County	104,820	105,104	0.27	116,193	10.85
Amarillo	165,050	165,497	0.27	183,897	11.42
Randall County	91,573	101,246	10.56	99,546	8.71
Total ROI Construction	203,159	213,707	5.19	223,758	10.14
Operation					
Carson County	6,793	6,950	2.32	7,343	8.1
Potter County	105,863	105,903	0.04	110,859	4.72
Amarillo	166,692	166,754	0.04	174,971	4.97
Randall County	92,485	95,062	2.79	95,987	3.79
Total ROI Operation	205,141	207,915	1.35	214,189	4.41

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; PX Census 1991a.

TABLE D.3-59.—Total Housing Units for Pantex Plant Region of Influence, 1970-2020

Jurisdiction	1970	1980	1990	2005	2010	2020
Carson County	2,333	2,635	2,856	2,938	2,950	2,992
Potter County	36,589	41,042	42,927	45,974	46,431	47,313
Amarillo	48,383	60,280	68,592	71,828	72,542	73,920
Randall County	17,346	28,544	37,807	38,608	38,992	39,733
Total ROI (County)	56,268	72,221	83,590	87,520	88,374	90,038

Source: Census 1972a; Census 1973a; Census 1977a; Census 1982a; PX Census 1991a.

TABLE D.3-60.—Changes to Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies for Pantex Plant Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Carson County	2,938	3,043	3.58	3,034	3.24	3,215	9.43	3,107	5.74	2,954	0.7
Potter County	45,974	46,927	2.07	46,839	1.88	48,496	5.48	47,504	3.33	46,007	0.47
Amarillo	71,828	73,399	2.19	73,254	1.99	75,985	5.79	74,363	3.53	71,894	0.49
Randall County	38,608	39,268	1.71	39,207	1.55	40,353	4.52	39,681	2.78	38,616	0.42
Total ROI	87,520	89,238	1.96	89,079	1.78	92,063	5.19	90,292	3.17	87,577	0.45
Operation											
Carson County	2,950	2,978	0.95	2,978	0.93	2,975	0.84	2,969	0.64	2,969	0.64
Potter County	46,431	46,685	0.55	46,679	0.53	46,638	0.49	46,601	0.37	46,601	0.37
Amarillo	72,542	72,960	0.58	72,951	0.56	72,916	0.51	72,823	0.39	72,823	0.39
Randall County	38,992	39,168	0.45	39,164	0.44	39,149	0.4	39,110	0.3	39,110	0.3
Total ROI	88,374	88,831	0.52	88,821	0.51	88,782	0.46	88,681	0.35	88,681	0.35

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX Census 1991a.

TABLE D.3-60A.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Region of Influence

Region of Influence	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Carson County	2,938	3,113	5.96	3,366	14.56
Potter County	45,974	46,068	0.2	49,855	8.44
Amarillo	71,828	71,976	0.21	78,260	8.96
Randall County	38,608	41,469	7.41	41,329	7.05
Total ROI	87,520	90,650	3.58	94,551	8.03
Operation					
Carson County	2,950	2,970	0.66	3,040	3.05
Potter County	46,431	46,443	0.03	47,247	1.76
Amarillo	72,542	72,561	0.03	73,894	1.86
Randall County	38,992	39,310	0.81	39,564	1.47
Total ROI	88,374	88,722	0.39	89,851	1.67

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; SNL 1995a; PX Census 1991a.

TABLE D.3-61.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Tritium Supply Technologies and Recycling for Pantex Plant Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)
Construction											
Carson County	2,938	3,092	5.2	3,076	4.65	3,264	11.04	3,156	7.4	2,977	1.49
Potter County	45,974	47,372	3.04	47,226	2.72	48,941	6.46	47,947	4.29	46,255	1.01
Amarillo	71,828	74,133	3.21	73,892	2.87	76,718	6.81	75,097	4.55	72,296	1.05
Randall County	38,608	39,576	2.51	39,475	2.24	40,661	5.32	39,991	3.58	38,804	0.91
Total ROI Construction	87,520	90,039	2.88	89,776	2.58	92,865	6.11	91,093	4.08	88,037	0.98
Operation											
Carson County	2,950	3,027	2.62	3,026	2.58	3,021	2.42	3,007	1.94	3,007	1.94
Potter County	46,431	47,134	1.51	47,123	1.49	47,080	1.4	46,967	1.16	46,967	1.16
Amarillo	72,542	73,702	1.60	73,684	1.57	73,611	1.47	73,426	1.22	73,426	1.22
Randall County	38,992	39,479	1.25	39,472	1.23	39,441	1.15	39,364	0.95	39,364	0.95
Total ROI Operation	88,374	89,641	1.43	89,621	1.41	89,542	1.32	89,338	1.09	89,338	1.09

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; SNL 1995a; PX Census 1991a.

**TABLE D.3-61A.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Region of Influence**

Region of Influence	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Carson County	2,938	3,163	7.65	3,415	16.22
Potter County	45,974	46,081	0.23	50,298	9.41
Amarillo	71,828	71,998	0.24	78,994	9.98
Randall County	38,608	42,286	9.53	41,640	7.85
Total ROI Construction	87,520	91,531	4.58	95,352	8.95
Operation					
Carson County	2,950	3,010	2.03	3,159	7.1
Potter County	46,431	46,446	0.03	48,331	4.09
Amarillo	72,542	72,566	0.03	75,690	4.34
Randall County	38,992	39,972	2.51	40,324	3.42
Total ROI Operation	88,374	89,428	1.19	91,814	3.89

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX Census 1991a.

TABLE D.3-62.—County and City Revenues and Expenditures for Pantex Plant Region of Influence, 1992

Revenues and Expenditures	Carson County	Potter County	Amarillo ^a	Randall County
Local sources (percent)	73	69	59	63
State revenues (percent)	1	4	12	2
Federal revenues (percent)	20	20	19	31
Other (percent)	5	7	9	4
Total Revenues (dollars)	1,604,751	16,561,508	65,950,257	10,515,627
General Government (percent)	69	35	8	40
Public safety, health, and community service (percent)	18	39	45	34
Public works, parks, culture, and recreation (percent)	0	7	44	15
Debt service (percent)	0	7	2	6
Other (percent)	13	12	2	5
Total Expenditures (dollars)	2,343,195	19,967,949	59,656,411	10,426,496
End-of-Year Fund Balance (dollars)	17,988	396,766	19,822,447	1,8838,147

^a Estimated from 1989-1991 financial audits and 1992 fiscal budgets.

Source: PX City 1991a; PX County 1992a.

TABLE D.3-63.—School District Revenues and Expenditures for Panter Plant Region of Influence, 1992

Revenues and Expenditures	Carson County			Potter County			Randall County		
	Groom District	Panhandle District	White Deer District	Amarillo District	Canyon District				
Local sources (percent)	56	85	92	46	47				47
State revenues (percent)	40	12	5	47	49				49
Federal revenues (percent)	5	3	3	7	4				4
Total Revenues (dollars)	1,341,890	4,240,134	2,809,639	112,974,576	23,512,715				
Total expenditures per pupil (dollars)	6,208	5,717	5,542	3,950	3,953				
Total instruction (percent)	55	57	52	59	57				57
School administration, services, and transportation (percent)	32	25	29	23	23				23
Maintenance, operation, and facilities acquisition (percent)	13	13	19	11	10				10
Other (percent)	0	5	0	7	11				11
Total Expenditures (dollars)	1,334,657	3,984,495	2,687,654	107,836,850	23,205,181				
End-of-Year Fund Balance (dollars)	635,058	1,718,148	995,296	20,591,936	4,701,437				

Source: PX School 1992a.

TABLE D.3-64.—Changes in County and City Total Revenues and Expenditures Over/Under No Action
During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies for Pantex Plant Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Carson County	1,629,404	1,696,223	4.1	1,690,624	3.76	1,793,232	10.05	1,730,505	6.2	1,666,376	2.45
Potter County	17,920,786	18,425,873	2.82	18,388,038	2.61	19,036,023	6.22	18,719,729	4.46	18,207,997	1.98
Amarillo	64,794,434	66,327,796	2.37	66,214,407	2.19	68,141,189	5.17	67,229,866	3.76	65,698,813	1.68
Randall County	9,857,208	10,127,355	2.74	10,108,601	2.55	10,415,161	5.66	10,294,751	4.44	10,022,876	2.08
Total ROI	94,201,832	96,577,247	2.52	96,401,670	2.34	99,385,604	5.50	97,974,851	4.01	95,596,062	1.79
County and City											
Revenues											
Expenditures											
Carson County	2,356,950	2,444,251	3.7	2,436,329	3.37	2,587,484	9.78	2,484,591	5.42	2,399,652	1.93
Potter County	19,039,510	19,440,077	2.1	19,403,161	1.91	20,099,440	5.57	19,626,160	3.08	19,183,249	1.1
Amarillo	56,736,350	57,843,984	1.95	57,741,969	1.77	59,666,525	5.16	58,358,353	2.86	57,119,479	1.02
Randall County	9,370,063	9,527,130	1.68	9,512,643	1.52	9,785,547	4.43	9,600,090	2.45	9,416,666	0.88
Total ROI	87,502,873	89,255,442	2	89,094,102	1.82	92,138,996	5.3	90,069,193	2.93	88,119,046	1.05
County and City											
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX City 1992a; PX County 1992a; PX DOC 1991a.

TABLE D.3-64A.—Changes in County and City Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 for Phased APT) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Carson County	1,629,404	1,738,154	6.67	1,816,737	11.5
Potter County	17,920,786	18,780,175	4.8	19,350,578	7.98
Amarillo	64,794,434	67,414,126	4.04	69,139,551	6.71
Randall County	9,857,208	10,327,854	4.77	10,626,470	7.8
Total ROI County and City Revenues	94,201,832	98,260,309	4.31	100,933,336	7.15
Expenditures					
Carson County	2,356,950	2,494,248	5.83	2,599,851	10.31
Potter County	19,039,510	19,670,545	3.31	20,152,282	5.84
Amarillo	56,736,350	58,481,070	3.08	59,813,544	5.42
Randall County	9,370,063	9,617,493	2.64	9,806,357	4.66
Total ROI County and City Expenditures	87,502,873	90,263,356	3.15	92,372,035	5.56

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX City 1992a; PX County 1992a; PX DOC 1991a.

TABLE D.3-65. Changes in County and City Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies for Pantex Plant Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Carson County	1,634,445	1,653,811	1.18	1,653,500	1.17	1,651,721	1.06	1,647,468	0.8	1,647,468	0.8
Potter County	18,086,368	18,248,061	0.89	18,244,661	0.88	18,230,769	0.8	18,194,887	0.6	18,194,887	0.6
Amarillo	65,293,540	65,789,530	0.76	65,980,314	1.05	65,736,273	0.68	65,626,448	0.51	65,626,448	0.51
Randall County	9,952,042	10,043,439	0.92	10,117,758	1.67	10,033,572	0.82	10,013,389	0.62	10,013,389	0.62
Total ROI County and City	94,966,395	95,734,841	0.81	95,996,233	1.08	95,652,335	0.72	95,482,193	0.54	95,482,193	0.54
Revenues											
Expenditures											
Carson County	2,363,542	2,386,830	0.99	2,386,513	0.97	2,384,295	0.88	2,379,225	0.66	2,379,225	0.66
Potter County	19,205,843	19,312,362	0.55	19,310,124	0.54	19,301,015	0.5	19,277,364	0.37	19,277,364	0.37
Amarillo	57,220,243	57,515,135	0.52	57,754,233	0.93	57,483,500	0.46	57,418,269	0.35	57,418,269	0.35
Randall County	9,454,965	9,496,841	0.44	9,586,481	1.39	9,492,313	0.4	9,483,078	0.3	9,483,078	0.3
Total ROI County and City	88,244,593	88,711,167	0.53	89,037,351	0.9	88,661,124	0.47	88,557,935	0.36	88,557,935	0.36
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX City 1992a; PX County 1992a; PX DOC 1991a.

**TABLE D.3-65A.—Changes in County and City Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Region of Influence**

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Carson County	1,634,445	1,653,116	1.14	1,696,372	3.79
Potter County	18,086,368	18,240,973	0.85	18,600,822	2.84
Amarillo	65,293,540	65,768,332	0.73	67,525,556	3.42
Randall County	9,952,042	10,039,578	0.88	10,490,618	5.41
Total ROI County and City Revenues	94,966,395	95,701,999	0.77	98,313,368	3.52
Expenditures					
Carson County	2,363,542	2,386,041	0.95	2,438,199	3.16
Potter County	19,205,843	19,307,665	0.53	19,544,757	1.76
Amarillo	57,220,243	57,502,809	0.49	58,955,709	3.03
Randall County	9,454,965	9,495,176	0.43	9,882,390	4.52
Total ROI County and City Expenditures	88,244,593	88,691,691	0.51	90,821,055	2.92

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX City 1992a; PX County 1992a; PX DOC 1991a.

TABLE D.3-66.—Changes in School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies for Pantex Plant Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Amarillo	105,624,268	108,150,051	2.39	107,917,279	2.17	112,307,691	6.33	109,323,405	3.50	106,527,836	1.26
Canyon	20,628,469	21,018,206	1.89	20,983,716	1.72	21,663,169	5.02	21,205,142	2.80	20,751,805	1
Groom	1,187,445	1,235,799	4.07	1,231,411	3.7	1,315,132	10.75	1,258,142	5.95	1,210,770	2.13
Panhandle	4,172,331	4,342,234	4.07	4,326,816	3.7	4,620,985	10.75	4,420,740	5.95	4,254,286	2.13
White Deer	2,780,218	2,892,098	4.02	2,880,910	3.62	3,076,700	10.66	2,950,276	6.12	2,830,340	2.01
Total ROI	134,392,731	137,638,388	2.42	137,340,133	2.19	142,983,678	6.39	139,157,704	3.55	135,575,038	1.27
School District											
Revenues											
Expenditures											
Amarillo	98,658,883	100,550,299	1.92	100,375,989	1.74	103,663,720	5.07	101,428,957	2.81	99,309,097	1.01
Canyon	20,399,581	20,739,259	1.67	20,709,199	1.52	21,301,381	4.42	20,902,184	2.46	20,505,679	0.88
Groom	1,146,607	1,193,299	4.07	1,189,062	3.7	1,269,903	10.75	1,214,873	5.95	1,169,130	2.13
Panhandle	3,832,845	3,988,924	4.07	3,974,760	3.7	4,244,994	10.75	4,061,042	5.95	3,908,132	2.13
White Deer	2,644,040	2,750,440	4.02	2,739,800	3.62	2,926,000	10.66	2,805,768	6.12	2,691,707	2.01
Total ROI	126,681,957	129,222,220	2.01	128,988,810	1.82	133,405,998	5.31	130,412,824	2.95	127,583,745	1.05
School District											
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX DOC 1991a; PX School 1992a.

**TABLE D.3-66A.—Changes in School District Total Revenues and Expenditures Over/Under No Action
During Peak Construction (2005 (2003 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor
for Pantex Plant Region of Influence**

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Amarillo	105,624,268	109,603,274	3.77	112,640,883	6.64
Canyon	20,628,469	21,248,772	3.01	21,715,525	5.27
Groom	1,187,445	1,263,491	6.4	1,321,982	11.33
Panhandle	4,172,331	4,439,534	6.4	4,645,054	11.33
White Deer	2,780,218	2,963,142	6.58	3,088,336	11.08
Total ROI School District Revenues	134,392,731	139,518,212	3.81	143,411,780	6.71
Expenditures					
Amarillo	98,658,883	101,638,535	3.02	103,913,228	5.33
Canyon	20,399,581	20,940,210	2.65	21,347,012	4.64
Groom	1,146,607	1,220,038	6.4	1,276,517	11.33
Panhandle	3,832,845	4,078,307	6.4	4,267,105	11.33
White Deer	2,644,040	2,818,004	6.58	2,937,066	11.08
Total ROI School District Expenditures	126,681,957	130,695,094	3.17	133,740,928	5.57

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX DOC 1991a; PX School 1992a.

TABLE D.3-67.—Changes in School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies for Pantex Plant Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Amarillo	106,675,281	107,346,939	0.63	107,332,831	0.62	107,275,394	0.56	107,126,259	0.42	107,126,259	0.42
Canyon	20,835,409	20,938,879	0.5	21,163,064	0.50	20,928,532	0.45	20,904,389	0.33	20,904,389	0.33
Groom	1,192,185	1,205,084	1.08	1,204,909	1.07	1,203,680	0.96	1,200,872	0.73	1,200,872	0.73
Panhandle	4,188,987	4,234,310	1.08	4,233,693	1.07	4,229,376	0.96	4,219,509	0.73	4,219,509	0.73
White Deer	2,791,406	2,819,376	1	2,819,376	1	2,819,376	1	2,813,782	0.8	2,813,782	0.8
Total ROI	135,683,269	136,544,588	0.63	136,753,873	0.79	136,456,359	0.57	136,264,811	0.43	136,264,811	0.43
School District											
Revenues											
Expenditures											
Amarillo	99,442,090	99,945,057	0.51	99,934,492	0.5	99,891,481	0.45	99,779,802	0.34	99,779,802	0.34
Canyon	20,579,729	20,669,909	0.44	20,865,299	1.39	20,660,891	0.39	20,639,849	0.29	20,639,849	0.29
Groom	1,151,185	1,163,640	1.08	1,163,470	1.07	1,162,284	0.96	1,159,572	0.73	1,159,572	0.73
Panhandle	3,848,146	3,889,781	1.08	3,889,215	1.07	3,885,249	0.96	3,876,184	0.73	3,876,184	0.73
White Deer	2,654,680	2,681,280	1	2,681,280	1	2,681,280	1	2,675,960	0.8	2,675,960	0.8
Total ROI	127,675,830	128,349,666	0.53	128,533,756	0.67	128,281,185	0.47	128,131,368	0.36	128,131,368	0.36
School District											
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX DOC 1991a; PX School 1992a.

**TABLE D.3-67A.—Changes in School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Region of Influence**

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Amarillo	106,675,281	107,317,325	0.6	108,812,319	2
Canyon	20,835,409	20,930,463	0.46	21,900,288	5.11
Groom	1,192,185	1,204,647	1.05	1,233,536	3.47
Panhandle	4,188,987	4,232,775	1.05	4,334,281	3.47
White Deer	2,791,406	2,815,125	0.85	2,882,309	3.26
Total ROI School District Revenues	135,683,269	136,500,335	0.6	139,162,733	2.56
Expenditures					
Amarillo	99,442,090	99,922,880	0.48	101,042,397	1.61
Canyon	20,579,729	20,662,574	0.4	21,507,832	4.51
Groom	1,151,185	1,163,218	1.05	1,191,113	3.47
Panhandle	3,848,146	3,888,371	1.05	3,981,618	3.47
White Deer	2,654,680	2,677,237	0.85	2,741,130	3.26
Total ROI School District Expenditures	127,675,830	128,314,280	0.5	130,464,090	2.18

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX DOC 1991a; PX School 1992a.

TABLE D.3-68.—Changes in County and City Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies and Recycling for Pantex Plant Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Carson County	1,629,404	1,723,698	5.79	1,714,662	5.23	1,820,707	11.74	1,754,232	7.66	1,692,120	4.04
Potter County	17,920,786	18,599,205	3.79	18,542,249	3.47	19,209,132	7.19	18,891,217	5.42	18,390,634	3.00
Amarillo	64,794,434	66,842,410	3.16	66,673,464	2.90	68,655,804	5.96	67,747,381	4.56	66,249,797	2.53
Randall County	9,857,208	10,209,044	3.57	10,182,202	3.30	10,496,900	6.49	10,383,749	5.34	10,116,887	3.04
Total ROI	94,201,832	97,374,191	3.37	97,112,577	3.09	100,182,542	6.35	98,776,579	4.86	96,449,438	2.70
County and City											
Revenues											
Expenditures											
Carson County	2,356,950	2,484,813	5.42	2,471,504	4.86	2,628,045	11.50	2,516,691	6.78	2,434,966	3.43
Potter County	19,039,510	19,627,211	3.09	19,565,845	2.76	20,286,575	6.55	19,773,644	3.86	19,345,931	1.96
Amarillo	56,736,350	58,361,172	2.86	58,191,473	2.56	60,183,712	6.08	58,765,622	3.58	57,569,682	1.82
Randall County	9,370,063	9,600,472	2.46	9,576,387	2.20	9,858,889	5.22	9,657,730	3.07	9,480,629	1.56
Total ROI	87,502,873	90,073,667	2.94	89,805,208	2.63	92,957,221	6.23	90,713,687	3.67	88,831,208	1.87
County and City											
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX City 1992a; PX County 1992a; PX DOC 1991a.

TABLE D.3-68A.—Changes in County and City Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 for Phased APT) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHIGR	Change (percent)
Revenues					
Carson County	1,629,404	1,761,704	8.12	1,878,359	15.28
Potter County	17,920,786	18,949,306	5.74	19,735,458	10.13
Amarillo	64,794,434	67,924,142	4.83	70,281,202	8.47
Randall County	9,857,208	10,415,267	5.66	10,806,188	9.63
Total ROI County and City Revenues	94,201,832	99,050,419	5.15	102,701,208	9.02
Expenditures					
Carson County	2,356,950	2,526,253	7.18	2,691,447	14.19
Potter County	19,039,510	19,817,588	4.09	20,576,407	8.07
Amarillo	56,736,350	58,887,093	3.79	60,985,311	7.49
Randall County	9,370,063	9,674,949	3.25	9,972,529	6.43
Total ROI County and City Expenditures	87,502,873	90,905,884	3.89	94,225,693	7.68

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX City 1992a; PX County 1992a; PX DOC 1991a.

**TABLE D.3-69.—Changes in County and City Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies and Recycling for Pantex Plant Region of Influence**

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Carson County	1,634,445	1,684,491	3.06	1,683,812	3.02	1,680,784	2.84	1,673,297	2.38	1,673,297	2.38
Potter County	18,086,368	18,472,081	2.13	18,466,823	2.10	18,445,746	1.99	18,391,652	1.69	18,391,652	1.69
Amarillo	65,293,540	66,466,932	1.80	66,451,082	1.77	66,387,305	1.68	66,224,138	1.43	66,224,138	1.43
Randall County	9,952,042	10,160,720	2.10	10,157,964	2.07	10,147,038	1.96	10,119,071	1.68	10,119,071	1.68
Total ROI	94,966,395	96,784,224	1.91	96,759,680	1.89	96,660,872	1.78	96,408,158	1.52	96,408,158	1.52
County and City											
Revenues											
Expenditures											
Carson County	2,363,542	2,428,025	2.73	2,427,075	2.69	2,422,955	2.51	2,412,815	2.08	2,412,815	2.08
Potter County	19,205,843	19,501,413	1.54	19,496,779	1.51	19,478,401	1.42	19,431,258	1.17	19,431,258	1.17
Amarillo	57,220,243	58,037,717	1.43	58,024,965	1.41	57,973,958	1.32	57,843,741	1.09	57,843,741	1.09
Randall County	9,454,965	9,570,907	1.23	9,569,096	1.21	9,561,852	1.13	9,543,381	0.94	9,543,381	0.94
Total ROI	88,244,593	89,538,062	1.47	89,517,915	1.44	89,437,166	1.35	89,231,195	1.12	89,231,195	1.12
County and City											
Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX City 1992a; PX County 1992a; PX DOC 1991a.

**TABLE D.3-69A.—Changes in County and City Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Region of Influence**

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Carson County	1,634,445	1,699,758	4.00	1,763,785	7.91
Potter County	18,086,368	18,609,823	2.89	19,083,160	5.51
Amarillo	65,293,540	66,892,427	2.45	68,326,301	4.64
Randall County	9,952,042	10,241,657	2.91	10,491,557	5.42
Total ROI County and City Revenues	94,966,395	97,443,666	2.61	99,664,803	4.95
Expenditures					
Carson County	2,363,542	2,444,938	3.44	2,529,998	7.04
Potter County	19,205,843	19,577,314	1.93	19,968,095	3.97
Amarillo	57,220,243	58,247,799	1.80	59,328,615	3.68
Randall County	9,454,965	9,600,638	1.54	9,753,987	3.16
Total ROI County and City Expenditures	88,244,593	89,870,688	1.84	91,580,695	3.78

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; PX City 1992a; PX County 1992a; PX DOC 1991a.

TABLE D.3-70.—Changes in School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 for Phased APT) from Tritium Supply Technologies and Recycling for Pantex Plant Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Amarillo	105,624,268	109,330,030	3.51	108,943,086	3.14	113,487,671	7.44	110,253,370	4.38	107,553,633	2.23
Canyon	20,628,469	21,201,003	2.78	21,142,370	2.49	21,845,966	5.90	21,343,516	3.47	20,914,495	1.80
Groom	1,187,445	1,258,265	5.96	1,250,894	5.34	1,337,598	12.65	1,275,922	7.45	1,230,329	3.78
Panhandle	4,172,331	4,421,172	5.96	4,395,271	5.34	4,699,924	12.65	4,483,212	7.45	4,323,014	3.78
White Deer	2,780,218	2,948,038	6.04	2,925,662	5.23	3,132,640	12.68	2,986,748	7.43	2,887,791	4.08
Total ROI	134,392,731	139,158,509	3.55	138,657,282	3.17	144,503,799	7.52	140,342,768	4.43	136,909,261	2.26
School District Revenues											
Expenditures											
Amarillo	98,658,883	101,433,919	2.81	101,144,158	2.52	104,547,340	5.97	102,125,355	3.51	100,077,258	1.79
Canyon	20,399,581	20,898,577	2.45	20,847,475	2.20	21,460,699	5.20	21,022,785	3.05	20,647,472	1.58
Groom	1,146,607	1,214,992	5.96	1,207,874	5.34	1,291,596	12.65	1,232,041	7.45	1,188,017	3.78
Panhandle	3,832,845	4,061,439	5.96	4,037,645	5.34	4,317,510	12.65	4,118,431	7.45	3,971,268	3.78
White Deer	2,644,040	2,803,640	6.04	2,782,360	5.23	2,979,200	12.68	2,840,454	7.43	2,746,344	4.08
Total ROI	126,681,957	130,412,567	2.94	130,019,511	2.63	134,596,345	6.25	131,339,067	3.68	128,630,357	1.88
School District Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; PX DOC 1991a; PX School 1992a.

TABLE D.3-70A.—Changes in School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Amarillo	105,624,268	110,530,464	4.64	115,315,217	9.17
Canyon	20,628,469	21,386,318	3.67	22,129,060	7.27
Groom	1,187,445	1,281,218	7.90	1,372,715	15.60
Panhandle	4,172,331	4,501,821	7.90	4,823,314	15.60
White Deer	2,780,218	2,999,111	7.87	3,204,914	15.28
Total ROI School District Revenues	134,392,731	140,698,932	4.69	146,845,219	9.27
Expenditures					
Amarillo	98,658,883	102,332,855	3.72	105,915,885	7.36
Canyon	20,399,581	21,060,089	3.24	21,707,431	6.41
Groom	1,146,607	1,237,155	7.90	1,325,505	15.60
Panhandle	3,832,845	4,135,526	7.90	4,430,860	15.60
White Deer	2,644,040	2,852,212	7.87	3,047,934	15.28
Total ROI School District Expenditures	126,681,957	131,617,837	3.90	136,427,616	7.69

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; PX DOC 1991a; PX School 1992a.

TABLE D.3-71.—Changes in School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies and Recycling for Pantex Plant Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Amarillo	106,675,281	108,539,011	1.75	108,509,788	1.72	108,393,906	1.61	108,096,644	1.33	108,096,644	1.33
Canyon	20,835,409	21,121,676	1.37	21,118,227	1.36	21,100,982	1.27	21,052,696	1.04	21,052,696	1.04
Groom	1,192,185	1,227,901	3.00	1,227,375	2.95	1,225,093	2.76	1,219,476	2.29	1,219,476	2.29
Panhandle	4,188,987	4,314,482	3.00	4,312,632	2.95	4,304,615	2.76	4,284,880	2.29	4,284,880	2.29
White Deer	2,791,406	2,875,316	3.01	2,875,316	3.01	2,869,722	2.81	2,852,940	2.20	2,852,940	2.20
Total ROI School	135,683,269	138,078,386	1.77	138,043,338	1.74	137,894,318	1.63	137,506,637	1.34	137,506,637	1.34
District Revenues											
Expenditures											
Amarillo	99,442,090	100,837,732	1.40	100,815,849	1.38	100,729,071	1.29	100,506,468	1.07	100,506,468	1.07
Canyon	20,579,729	20,829,227	1.21	20,826,221	1.20	20,811,191	1.12	20,769,107	0.92	20,769,107	0.92
Groom	1,151,185	1,185,672	3.00	1,185,164	2.95	1,182,960	2.76	1,177,537	2.29	1,177,537	2.29
Panhandle	3,848,146	3,963,430	3.00	3,961,730	2.95	3,954,365	2.76	3,936,236	2.29	3,936,236	2.29
White Deer	2,654,680	2,734,480	3.01	2,734,480	3.01	2,729,160	2.81	2,713,200	2.20	2,713,200	2.20
Total ROI School	127,675,830	129,550,540	1.47	129,523,443	1.45	129,406,748	1.36	129,102,549	1.12	129,102,549	1.12
District Expenditures											

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; PX DOC 1991a; PX School 1992a.

TABLE D.3-71A.—Changes in School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor for Pantex Plant Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Amarillo	106,675,281	109,017,602	2.20	111,481,690	4.51
Canyon	20,835,409	21,194,105	1.72	21,576,392	3.56
Groom	1,192,185	1,237,269	3.78	1,284,381	7.73
Panhandle	4,188,987	4,347,396	3.78	4,512,936	7.73
White Deer	2,791,406	2,896,126	3.75	3,011,250	7.88
Total ROI School District Revenues	135,683,269	138,692,498	2.22	141,866,649	4.56
Expenditures					
Amarillo	99,442,090	101,196,122	1.76	103,041,337	3.62
Canyon	20,579,729	20,892,353	1.52	21,225,538	3.14
Groom	1,151,185	1,194,717	3.78	1,240,209	7.73
Panhandle	3,848,146	3,993,666	3.78	4,145,736	7.73
White Deer	2,654,680	2,754,270	3.75	2,863,756	7.88
Total ROI School District Expenditures	127,675,830	130,031,128	1.84	132,516,576	3.79

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; PX DOC 1991a; PX School 1992a.

TABLE D.3-72.—Distribution of Employees by Place of Residence for Savannah River Site, 1991

County/City	Number of Employees	Total Site Employment (percent)
Aiken County	9,978	51.9
Aiken	4,928	25.7
North Augusta	2,666	13.9
Barnwell County	1,401	7.3
Columbia County	2,036	10.6
Richmond County	3,358	17.5
Augusta	2,780	14.5
Total ROI (County)	16,773	87.3

Source: SRS 1991a:3.

TABLE D.3-73.—Employment and Local Economy Statistics for Savannah River Site Regional Economic Area, 1970-2020

Regional Economic Area	1970	1980	1990	2005	2010	2020
Civilian labor force	276,846	397,236	514,763	588,416	603,918	593,201
Total employment	263,975	369,004	489,855	559,944	574,696	564,498
Unemployment rate (percent)	4.6	7.1	4.8	4.8	4.8	4.8
Personal income (thousand dollars)	2,161,380	6,713,182	15,843,875	22,031,409	23,674,107	26,221,085
Per capita income (dollars per person)	2,873	7,210	15,012	19,049	19,978	21,335

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; SR ESC 1991a.

TABLE D.3-74.—Changes in Total Employment, Unemployment Rate, and Per Capita Income
During Peak Construction (2005 (2003 Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies and Recycling Upgrade and Phaseout for Savannah River Site Regional Economic Area

Regional Economic Area	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)	Tritium Recycle Phaseout	Change (percent)
Construction													
Total employment	559,944	567,143	1.29	566,807	1.23	570,739	1.93	568,488	1.53	559,114	0.90		
Unemployment rate (percent)	4.8	3.9	NA	4.0	NA	3.9	NA	3.9	NA	4.1	NA	NA	NA
Per capita income (dollars per person)	19,049	19,222	0.91	19,215	0.87	19,218	0.89	19,230	0.95	18,832	0.76		
Operation													
Total employment	574,696	577,079	0.41	577,028	0.41	576,823	0.37	576,295	0.28	576,295	0.28	573,889	-0.14
Unemployment rate (percent)	4.8	4.5	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.9	NA
Per capita income (dollars per person)	19,978	20,033	0.27	20,032	0.27	20,027	0.24	20,015	0.18	20,015	0.18	19,960	-0.09

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR ESC 1991a; SR DOE 1995a.

TABLE D.3-74A.—Changes in Total Employment, Unemployment Rate, and Per Capita Income During Peak Construction (2005 (2003 Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor Upgrade and Phaseout for Savannah River Site Regional Economic Area

Regional Economic Area	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Total employment	559,944	569,405	1.69	573,943	2.50
Unemployment rate (percent)	4.8	3.8	NA	3.9	NA
Per capita income (dollars per person)	19,049	19,250	1.06	19,200	0.79
Operation					
Total employment	574,696	576,487	0.31	579,943	0.91
Unemployment rate (percent)	4.8	4.6	NA	4.2	NA
Per capita income (dollars per person)	19,978	20,019	0.21	20,098	0.60

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOC 1990a; DOC 1990b; DOC 1991a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR ESC 1991a; SR DOE 1995a.

TABLE D.3-75.—Population for Savannah River Site Region of Influence, 1970-2020

Region of Influence	1970	1980	1990	2005	2010	2020
Aiken County	91,023	105,625	120,940	131,773	134,898	139,620
Aiken	13,436	14,978	19,872	21,652	22,166	22,941
North Augusta	12,883	13,593	15,351	16,726	17,123	17,722
Barnwell County	17,176	19,868	20,293	22,520	23,054	23,861
Columbia County	22,327	40,118	66,031	70,494	72,612	75,589
Richmond County	162,437	181,629	189,719	217,776	224,320	233,517
Augusta	59,864	47,532	44,639	51,241	52,780	54,944
Total ROI (County)	292,963	347,240	396,983	442,563	454,884	472,587

Source: Census 1973a; Census 1977a; Census 1983a; SR Census 1991a; SR Census 1991b.

TABLE D.3-76.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies and Recycling Upgrade and Phaseout for Savannah River Site Region of Influence

Region of Influence	No Action	HWR	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)	Tritium Recycle Phaseout	Change (percent)
Construction													
Aiken County	131,773	133,873	1.59	133,726	1.48	138,192	4.87	135,154	2.57	130,955	0.32		
Aiken	21,652	22,692	4.80	22,619	4.47	24,831	14.68	23,326	7.73	21,621	0.80		
North Augusta	16,726	17,288	3.36	17,249	3.13	18,445	10.28	17,632	5.42	16,666	0.58		
Barnwell County	22,520	22,815	1.31	22,795	1.22	23,423	4.01	22,995	2.11	22,371	0.28	NA	NA
Columbia County	70,494	70,923	0.61	70,893	0.57	71,805	1.86	71,185	0.98	69,781	0.17		
Richmond County	217,776	218,484	0.33	218,435	0.30	219,941	0.99	218,916	0.52	215,482	0.13		
Augusta	51,241	51,827	1.14	51,786	1.06	53,034	3.50	52,185	1.84	50,764	0.25		
Total ROI	442,563	446,095	0.80	445,849	0.74	453,361	2.44	448,250	1.29	438,589	0.20		
Operation													
Aiken County	134,898	135,625	0.54	135,610	0.53	135,547	0.48	135,386	0.36	135,386	0.36	134,652	-0.18
Aiken	22,166	22,526	1.63	22,518	1.59	22,487	1.45	22,408	1.09	22,408	1.09	22,044	-0.55
North Augusta	17,123	17,318	1.14	17,314	1.12	17,297	1.02	17,254	0.77	17,254	0.77	17,057	-0.38
Barnwell County	23,054	23,156	0.44	23,154	0.44	23,145	0.40	23,123	0.30	23,123	0.30	23,019	-0.15
Columbia County	72,612	72,760	0.20	72,757	0.20	72,745	0.18	72,712	0.14	72,712	0.14	72,562	-0.07
Richmond County	224,320	224,565	0.11	224,560	0.11	224,539	0.10	224,485	0.07	224,485	0.07	224,237	-0.04
Augusta	52,780	52,983	0.38	52,979	0.38	52,961	0.34	52,916	0.26	52,916	0.26	52,711	-0.13
Total ROI	454,884	456,106	0.27	456,081	0.26	455,976	0.24	455,706	0.18	455,706	0.18	454,470	-0.09

Note: NA -- not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR Census 1991a; SR Census 1991b; SR DOE 1995a.

TABLE D.3-76A.—Changes in Population During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor Upgrade and Phaseout for Savannah River Site Region of Influence

Region of Influence	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Aiken County	131,773	135,585	2.89	142,495	8.14
Aiken	21,652	23,338	7.79	26,962	24.52
North Augusta	16,726	17,641	5.47	19,598	17.17
Barnwell County	22,520	23,007	2.16	24,028	6.7
Columbia County	70,494	71,222	1.03	72,684	3.11
Richmond County	217,776	219,031	0.58	221,392	1.66
Augusta	51,241	52,212	1.9	54,236	5.85
Total ROI Construction	442,563	448,845	1.42	460,599	4.08
Operation					
Aiken County	134,898	135,397	0.37	136,498	1.19
Aiken	22,166	22,409	1.1	22,957	3.57
North Augusta	17,123	17,254	0.77	17,551	2.5
Barnwell County	23,054	23,124	0.3	23,279	0.98
Columbia County	72,612	72,718	0.15	72,939	0.45
Richmond County	224,320	224,504	0.08	224,859	0.24
Augusta	52,780	52,921	0.27	53,227	0.85
Total ROI Operation	454,884	455,743	0.19	457,575	0.59

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; SNL 1995a; SR Census 1991a; SR Census 1991b; SR DOE 1995a.

TABLE D.3-77.—Total Housing Units for Savannah River Site Region of Influence, 1970-2020

Region of Influence	1970	1980	1990	2005	2010	2020
Aiken County	29,400	39,791	49,266	53,679	54,942	56,875
Aiken	4,759	6,173	8,543	9,308	9,529	9,862
North Augusta	4,342	5,470	6,810	7,420	7,596	7,862
Barnwell County	5,384	7,282	7,854	8,716	8,922	9,235
Columbia County	6,740	14,099	23,745	25,350	26,112	27,182
Richmond County	47,751	64,846	77,288	88,718	91,384	95,130
Augusta	21,159	20,825	21,588	24,781	25,525	26,572
Total ROI (County)	89,275	126,018	158,153	176,463	181,370	188,423

Source: Census 1972a; Census 1973a; Census 1977a; Census 1982a; Census 1983a; SR Census 1991a; SR Census 1991b.

**TABLE D.3-78.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010)
from Tritium Supply Technologies and Recycling Upgrade and Phaseout for Savannah River Site Region of Influence**

Region of Influence	No Action	HW	Change (percent)	MHTGR	Change (percent)	ALWR	Change (percent)	Full APT	Change (percent)	Phased APT	Change (percent)	Tritium Recycle Phaseout	Change (percent)
Construction													
Aiken County	53,679	54,477	1.49	54,422	1.38	56,120	4.55	54,964	2.39	53,335	0.29		
Aiken	9,308	9,704	4.25	9,676	3.95	10,517	12.99	9,945	6.84	9,286	0.71		
North Augusta	7,420	7,637	2.88	7,622	2.68	8,077	8.8	7,505	4.64	7,386	0.5		
Barnwell County	8,716	8,828	1.29	8,820	1.20	9,059	3.94	8,897	2.07	8,658	0.27	NA	NA
Columbia County	25,350	25,513	0.64	25,502	0.60	25,848	1.97	25,613	1.04	25,096	0.18		
Richmond County	88,718	88,987	0.30	88,968	0.28	89,541	0.93	89,151	0.49	87,776	0.12		
Augusta	24,781	25,004	0.90	24,988	0.84	25,463	2.75	25,140	1.45	24,537	0.20		
Total ROI	176,463	177,806	0.76	177,712	0.71	180,568	2.33	178,625	1.23	174,864	0.19		
Operation													
Aiken County	54,952	55,228	0.50	55,223	0.49	55,199	0.45	55,137	0.34	55,137	0.34	54,852	-0.18
Aiken	9,529	9,666	1.44	9,663	1.41	9,651	1.28	9,621	0.97	9,621	0.97	9,477	-0.55
North Augusta	7,596	7,674	0.98	7,672	0.96	7,666	0.87	7,649	0.66	7,649	0.66	7,570	-0.38
Barnwell County	8,922	8,961	0.44	8,961	0.43	8,957	0.39	8,949	0.30	8,949	0.30	8,909	-0.15
Columbia County	26,112	26,168	0.22	26,167	0.21	26,162	0.19	26,150	0.15	26,150	0.15	26,094	-0.07
Richmond County	91,384	91,477	0.10	91,475	0.10	91,467	0.09	91,447	0.07	91,447	0.07	91,350	-0.04
Augusta	25,525	25,602	0.30	25,601	0.30	25,594	0.27	25,577	0.20	25,577	0.20	25,492	-0.13
Total ROI	181,370	181,835	0.26	181,825	0.25	181,785	0.23	181,682	0.17	181,682	0.17	181,204	-0.09
Operation													

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR Census 1991a; SR Census 1991b; SR DOE 1995a.

TABLE D.3-78A.—Changes in Housing Demands During Peak Construction (2005 (2003 for Phased APT)) and Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor Upgrade and Phaseout for Savannah River Site Region of Influence

Region of Influence	No Action	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Construction					
Aiken County	53,679	55,128	2.70	57,756	7.59
Aiken	9,308	9,949	6.89	11,327	21.69
North Augusta	7,429	7,777	4.68	8,521	14.70
Barnwell County	8,716	8,901	2.13	9,289	6.58
Columbia County	25,350	25,627	1.09	26,183	3.28
Richmond County	88,718	89,195	0.54	90,093	1.55
Augusta	24,781	25,150	1.49	25,920	4.60
Total ROI Construction	176,463	178,851	1.35	183,320	3.89
Operation					
Aiken County	54,952	55,142	0.35	55,560	1.11
Aiken	9,529	9,622	0.97	9,830	3.16
North Augusta	7,605	7,655	0.66	7,768	2.14
Barnwell County	8,922	8,949	0.30	9,008	0.96
Columbia County	26,112	26,152	0.15	26,236	0.48
Richmond County	91,384	91,454	0.08	91,589	0.22
Augusta	25,525	25,579	0.21	25,695	0.67
Total ROI Operation	181,370	181,696	0.18	182,393	0.56

Note: NA - not applicable.

Source: Census 1973a; Census 1977a; Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR Census 1991a; SR Census 1991b; SR DOE 1995a.

TABLE D.3-79.—County and City Revenues and Expenditures for Savannah River Site Region of Influence, 1992

Revenues and Expenditures	Aiken County ^a		North Augusta		Barnwell County		Columbia County		Richmond County		Augusta	
	County	City	County	City	County	City	County	City	County	City	County	City
Property tax (percent)	59		43		25		74		74		58	
State shared and intergovernmental (percent)	23		8		73		7		0		21	
Permits, fees, fines, and investment interest (percent)	17		49		0		10		15		14	
Other (percent)	1		1		3		9		11		7	
Total Revenues (dollars)	26,055,374		11,504,145		7,390,553		25,758,888		87,230,497		33,282,930	
General Government (percent)	22		8		37		12		28		23	
Public safety, health, and welfare (percent)	26		31		38		36		35		31	
Public works, fees, fines, and investment interest (percent)	20		30		17		17		11		19	
Debt service (percent)	16		3		0		1		3		5	
Capital project (percent)	11		12		0		10		23		22	
Other (percent)	5		16		8		24		0		0	
Total Expenditures (dollars)	30,782,399		11,639,638		5,065,164		23,474,763		87,079,716		39,603,007	
End-of-Year Fund Balance (dollars)	464,670		8,327,903		5,472,719		5,060,786		38,041,195		8,024,752	

^a Estimated from 1989 through 1991 financial audits and 1992 fiscal budgets.
Source: SR City 1992a; SR County 1992a.

TABLE D.3-80.—School District Revenues and Expenditures for Savannah River Site Region of Influence, 1992

Revenues and Expenditures	School District					
	Aiken County	Barnwell County #19	Barnwell County #29	Barnwell County #45 ^a	Columbia County	Richmond County
Local sources (percent)	39	19	21	25	33	33
Intermediate sources (percent)	0	0	4	1	0	0
State sources (percent)	55	64	67	58	64	58
Federal source (percent)	6	17	8	16	3	9
Total Revenues (dollars)	97,408,101	5,830,056	8,105,837	10,928,093	51,511,933	144,200,546
Total expenditures per pupil (dollars)	4,409	4,016	2,569	4,700	4,322	4,608
Total instructions (percent)	51	59	19	52	54	55
Support services (percent)	29	38	4	23	26	31
Food, community, and other services (percent)	1	1	67	20	4	5
Capital assets (percent)	7	0	8	0	12	7
Debt service (percent)	11	2	0	6	4	2
Total Expenditures (dollars)	107,031,526	5,187,885	8,105,837	12,075,596	57,292,094	149,113,505
End-of-Year Fund Balance (dollars)	14,249,675	710,596	789,567	72,937	21,629,630	18,290,485

^a Estimated from 1989 through 1991 financial audits and 1992 fiscal budgets.

Source: SR School 1992a.

TABLE D.3-81.—Changes in County and City Total Revenues and Expenditures Over/Under No Action
During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies and Recycling Upgrade
for Savannah River Site Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Aiken County	27,054,664	27,375,525	1.19	27,353,256	1.1	28,011,815	3.54	27,435,210	1.41	27,027,887	0.58
Aiken	12,212,286	12,445,274	1.91	12,430,629	1.79	12,768,647	4.56	12,561,177	2.86	12,271,201	1.26
North Augusta	6,026,503	6,144,024	1.95	6,136,724	1.83	6,299,204	4.53	6,206,637	2.99	6,060,150	1.33
Barnwell County	4,380,812	4,409,653	0.66	4,407,700	0.61	4,468,419	2	4,414,255	0.76	4,371,385	0.31
Columbia County	24,730,949	24,854,572	0.5	24,845,926	0.46	25,106,458	1.52	24,874,515	0.58	24,545,596	0.23
Richmond County	94,851,377	95,226,892	0.4	95,203,372	0.37	95,801,958	1	95,370,534	0.55	94,097,580	0.24
Augusta	36,080,288	36,194,320	0.32	36,187,167	0.3	36,369,793	0.8	36,237,562	0.44	35,856,337	0.19
Total ROI	205,336,878	206,650,259	0.64	206,564,774	0.6	208,826,293	1.7	207,099,891	0.86	204,230,136	0.37
Revenues											
Expenditures											
Aiken County	31,113,945	31,209,753	0.31	31,203,047	0.29	31,404,916	0.94	31,224,870	0.36	31,122,287	0.14
Aiken	12,146,828	12,248,029	0.83	12,240,945	0.77	12,454,175	2.53	12,263,997	0.96	12,122,004	0.38
North Augusta	7,640,305	7,706,586	0.87	7,701,947	0.81	7,841,600	2.63	7,717,044	1	7,603,258	0.4
Barnwell County	4,824,019	4,840,531	0.34	4,839,413	0.32	4,874,176	1.04	4,843,166	0.4	4,808,847	0.16
Columbia County	21,999,236	22,113,180	0.52	22,105,211	0.48	22,345,344	1.57	22,131,562	0.6	21,822,025	0.24
Richmond County	93,276,562	93,464,763	0.2	93,451,733	0.19	93,848,485	0.61	93,493,985	0.23	92,689,605	0.09
Augusta	40,061,036	40,144,914	0.21	40,139,107	0.19	40,315,933	0.64	40,157,938	0.24	39,757,409	0.1
Total ROI	211,061,931	211,727,756	0.32	211,681,402	0.29	213,084,629	0.96	211,832,561	0.37	209,925,436	0.14
Expenditures											

Source: Census 1973a; Census 1977a, Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR City 1992a; SR County 1992a; SR ESC 1991a; SR DOE 1995a.

TABLE D.3-81A.—Changes in County and City Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor Upgrade for Savannah River Site Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Aiken County	27,054,664	27,461,672	1.5	27,962,386	3.36
Aiken	12,212,286	12,585,437	3.06	12,876,047	5.44
North Augusta	6,026,503	6,219,163	3.2	6,361,574	5.56
Barnwell County	4,380,812	4,416,581	0.82	4,462,552	1.87
Columbia County	24,730,949	24,884,498	0.62	25,080,479	1.41
Richmond County	94,851,377	95,406,635	0.59	95,921,444	1.13
Augusta	36,080,288	36,248,499	0.47	36,405,201	0.9
Total ROI Revenues	205,336,878	207,222,485	0.92	209,069,683	1.82
Expenditures					
Aiken County	31,113,945	31,232,583	0.38	31,384,815	0.87
Aiken	12,146,828	12,272,144	1.03	12,432,943	2.36
North Augusta	7,640,305	7,722,380	1.07	7,827,695	2.45
Barnwell County	4,824,019	4,844,497	0.42	4,870,817	0.97
Columbia County	21,999,236	22,140,763	0.64	22,321,399	1.46
Richmond County	93,276,562	93,509,104	0.25	93,809,083	0.57
Augusta	40,061,036	40,164,676	0.26	40,298,372	0.59
Total ROI Expenditures	211,061,931	211,886,148	0.39	212,945,123	0.89

Source: Census 1973a; Census 1977a, Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR City 1992a; SR County 1992a; SR ESC 1991a; SR DOE 1995a.

TABLE D.3-82.—Changes to County and City Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies and Recycling Upgrade and Phaseout for Savannah River Site Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	APT		APT		Tritium Recycle Phaseout	
								Full (\$)	Change (percent)	Phased (\$)	Change (percent)	(\$)	Change (percent)
Revenues													
Aiken County	27,519,712	27,630,704	0.4	27,628,660	0.4	27,618,790	0.36	27,594,198	0.27	27,594,198	0.27	27,481,977	-0.14
Aiken	12,456,386	12,536,766	0.65	12,537,271	0.65	12,528,139	0.58	12,510,332	0.43	12,510,332	0.43	12,428,209	-0.23
North Augusta	6,143,551	6,184,083	0.66	6,184,451	0.67	6,179,733	0.59	6,170,753	0.44	6,170,753	0.44	6,129,293	-0.23
Barnwell County	4,431,083	4,441,070	0.23	4,440,875	0.22	4,439,996	0.2	4,437,848	0.15	4,437,848	0.15	4,427,696	-0.08
Columbia County	25,338,535	25,381,104	0.17	25,380,239	0.16	25,376,781	0.15	25,367,270	0.11	25,367,270	0.11	25,324,041	-0.06
Richmond County	97,287,668	97,413,903	0.13	97,412,306	0.13	97,400,458	0.12	97,372,586	0.09	97,372,586	0.09	97,242,990	-0.05
Augusta	36,824,758	36,863,108	0.1	36,862,619	0.1	36,859,024	0.09	36,850,557	0.07	36,850,557	0.07	36,811,193	-0.04
Total ROI	210,001,693	210,450,738	0.21	210,446,421	0.21	210,402,921	0.19	210,303,545	0.14	210,303,545	0.14	209,845,399	-0.07
Revenues													
Expenditures													
Aiken County	31,271,127	31,304,277	0.11	31,303,593	0.1	31,300,719	0.09	31,293,374	0.07	31,293,374	0.07	31,259,889	-0.04
Aiken	12,295,264	12,330,279	0.28	12,329,557	0.28	12,326,521	0.25	12,318,763	0.19	12,318,763	0.19	12,283,393	-0.1
North Augusta	7,733,322	7,756,255	0.30	7,755,782	0.29	7,753,793	0.26	7,748,712	0.2	7,748,712	0.2	7,725,547	-0.1
Barnwell County	4,849,991	4,855,709	0.12	4,855,597	0.12	4,855,094	0.11	4,853,864	0.08	4,853,864	0.08	4,848,052	-0.04
Columbia County	22,551,729	22,590,965	0.17	22,590,168	0.17	22,586,981	0.16	22,578,215	0.12	22,578,215	0.12	22,538,370	-0.06
Richmond County	95,025,304	95,090,422	0.07	95,089,092	0.07	95,083,508	0.06	95,069,148	0.05	95,069,148	0.05	95,003,200	-0.02
Augusta	40,834,768	40,863,790	0.07	40,863,197	0.07	40,860,708	0.06	40,854,308	0.05	40,854,308	0.05	40,824,916	-0.02
Total ROI	214,561,504	214,791,696	0.11	214,786,985	0.11	214,767,323	0.1	214,716,384	0.07	214,716,384	0.07	214,483,366	-0.04
Expenditures													

Source: Census 1973a; Census 1977a, Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR City 1992a; SR County 1992a; SR ESC 1991a; SR DOE 1995a.

TABLE D.3-82A.—Changes to County and City Total Revenues and Expenditures Over/Under No Action at Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor Upgrade and Phaseout for Savannah River Site Region of Influence

	Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues						
Aiken County		27,519,712	27,626,129	0.39	27,873,794	1.29
Aiken		12,456,386	12,533,413	0.62	12,719,261	2.11
North Augusta		6,143,551	6,182,389	0.63	6,276,476	2.16
Barnwell County		4,431,083	4,440,666	0.22	4,462,906	0.72
Columbia County		25,338,535	25,379,292	0.16	25,474,074	0.53
Richmond County		97,287,668	97,408,798	0.12	97,692,743	0.42
Augusta		36,824,758	36,861,557	0.1	36,947,805	0.33
Total ROI Revenues		210,001,693	210,432,244	0.21	211,447,059	0.69
Expenditures						
Aiken County		31,271,127	31,302,912	0.1	31,376,640	0.34
Aiken		12,295,264	12,328,838	0.27	12,406,715	0.91
North Augusta		7,733,322	7,755,311	0.28	7,806,316	0.94
Barnwell County		4,849,991	4,855,477	0.11	4,868,210	0.38
Columbia County		22,551,729	22,589,295	0.17	22,676,656	0.55
Richmond County		95,025,304	95,087,811	0.07	95,232,616	0.22
Augusta		40,834,768	40,862,626	0.07	40,927,163	0.23
Total ROI Expenditures		214,561,504	214,782,271	0.1	215,294,317	0.34

Source: Census 1973a; Census 1977a, Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR City 1992a; SR County 1992a; SR ESC 1991a; SR DOE 1995a.

TABLE D.3-83.—Changes in School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Tritium Supply Technologies and Recycling Upgrade for Savannah River Site Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)
Revenues											
Aiken County	104,818,039	106,488,579	1.59	106,371,648	1.48	109,891,491	4.84	106,752,163	1.85	104,595,705	0.73
Barnwell County #19	5,534,346	5,587,394	0.96	5,583,803	0.89	5,695,485	2.91	5,595,860	1.11	5,518,295	0.45
Barnwell County #29	4,481,168	4,506,901	0.57	4,505,159	0.54	4,559,337	1.74	4,511,008	0.67	4,472,403	0.27
Barnwell County #45	11,931,968	12,087,450	1.3	12,076,924	1.21	12,404,264	3.96	12,112,263	1.51	11,895,436	0.63
Columbia County	54,178,029	54,401,160	0.41	54,385,555	0.38	54,855,799	1.25	54,437,156	0.48	53,842,465	0.19
Richmond County	156,300,012	156,651,709	0.23	156,627,359	0.21	157,368,781	0.68	156,706,317	0.26	155,193,871	0.11
Total School District Revenues	337,243,562	339,723,193	0.74	339,550,449	0.68	344,775,157	2.23	340,114,767	0.85	335,518,176	0.34
Expenditures											
Aiken County	110,683,758	112,163,651	1.34	112,060,065	1.24	115,178,215	4.06	112,397,154	1.55	110,479,007	0.61
Barnwell County #19	5,634,645	5,706,512	1.28	5,701,647	1.19	5,852,950	3.87	5,717,981	1.48	5,616,665	0.59
Barnwell County #29	4,524,924	4,582,917	1.28	4,578,992	1.19	4,701,088	3.89	4,592,173	1.49	4,510,182	0.6
Barnwell County #45	12,819,287	12,948,398	1.01	12,939,658	0.94	13,211,479	3.06	12,969,003	1.17	12,789,777	0.48
Columbia County	60,449,018	60,758,215	0.51	60,736,590	0.48	61,388,213	1.55	60,808,095	0.59	59,970,644	0.24
Richmond County	156,897,416	157,064,087	0.11	157,052,548	0.1	157,403,911	0.32	157,089,967	0.12	156,352,305	0.05
Total School District Expenditures	351,009,048	353,223,781	0.63	353,069,499	0.59	357,735,857	1.92	353,574,373	0.73	349,718,579	0.29

Source: Census 1973a; Census 1977a, Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR ESC 1991a; SR DOE 1995a; SR School 1992a.

TABLE D.3-83A.—Changes in School District Total Revenues and Expenditures Over/Under No Action During Peak Construction (2005 (2003 for Phased APT)) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor Upgrade for Savannah River Site Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Aiken County	104,818,039	106,886,655	1.97	109,541,010	4.51
Barnwell County #19	5,534,346	5,600,137	1.19	5,684,694	2.72
Barnwell County #29	4,481,168	4,513,083	0.71	4,554,102	1.63
Barnwell County #45	11,931,968	12,124,800	1.62	12,372,634	3.69
Columbia County	54,178,029	54,455,175	0.51	54,808,908	1.16
Richmond County	156,300,012	156,734,570	0.28	157,295,148	0.64
Total School District Revenues	337,243,562	340,314,421	0.91	344,256,497	2.08
Expenditures					
Aiken County	110,683,758	112,516,298	1.66	114,867,732	3.78
Barnwell County #19	5,634,645	5,723,776	1.58	5,838,330	3.61
Barnwell County #29	4,524,924	4,596,849	1.59	4,689,290	3.63
Barnwell County #45	12,819,287	12,979,414	1.25	13,185,214	2.85
Columbia County	60,449,018	60,833,064	0.64	61,323,237	1.45
Richmond County	156,897,416	157,103,356	0.13	157,369,017	0.3
Total School District Expenditures	351,009,048	353,752,756	0.78	357,272,820	1.78

Source: Census 1973a; Census 1977a, Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR ESC 1991a; SR DOE 1995a; SR School 1992a.

TABLE D.3-84.—Changes in School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010)
from Tritium Supply Technologies and Recycling Upgrade and Phaseout for Savannah River Site Region of Influence

Jurisdiction	No Action (\$)	HWR (\$)	Change (percent)	MHTGR (\$)	Change (percent)	ALWR (\$)	Change (percent)	Full APT (\$)	Change (percent)	Phased APT (\$)	Change (percent)	Recycle Phaseout (\$)	Change (percent)
Revenues													
Aiken County	107,304,188	107,882,198	0.54	107,870,266	0.53	107,820,153	0.48	107,692,086	0.36	107,692,086	0.36	107,108,230	-0.18
Barnwell County #19	5,627,386	5,645,755	0.33	5,645,396	0.32	5,643,780	0.29	5,639,830	0.22	5,639,830	0.22	5,621,156	-0.11
Barnwell County #29	4,526,886	4,535,797	0.2	4,535,622	0.19	4,534,839	0.18	4,532,922	0.13	4,532,922	0.13	4,523,864	-0.07
Barnwell County #45	12,213,030	12,266,871	0.44	12,265,818	0.43	12,261,082	0.39	12,249,504	0.3	12,249,504	0.3	12,194,772	-0.15
Columbia County	55,269,463	55,346,297	0.14	55,344,736	0.14	55,338,494	0.12	55,321,328	0.09	55,321,328	0.09	55,243,301	-0.05
Richmond County	159,553,179	159,674,867	0.08	159,672,382	0.07	159,661,947	0.07	159,635,112	0.05	159,635,112	0.05	159,511,873	-0.03
Total School District	344,494,131	345,351,784	0.25	345,334,221	0.24	345,260,294	0.22	345,070,783	0.17	345,070,783	0.17	344,203,196	-0.08
Revenues													
Expenditures													
Aiken County	112,875,249	113,387,295	0.45	113,376,725	0.44	113,332,331	0.4	113,218,880	0.3	113,218,880	0.3	112,701,654	-0.15
Barnwell County #19	5,764,535	5,789,421	0.43	5,788,935	0.42	5,786,746	0.39	5,781,394	0.29	5,781,394	0.29	5,756,096	-0.15
Barnwell County #29	4,629,708	4,649,790	0.43	4,649,398	0.43	4,647,631	0.39	4,643,313	0.29	4,643,313	0.29	4,622,898	-0.15
Barnwell County #45	13,053,960	13,098,669	0.34	13,097,794	0.34	13,093,861	0.31	13,084,247	0.23	13,084,247	0.23	13,038,798	-0.12
Columbia County	61,956,151	62,062,621	0.17	62,060,458	0.17	62,051,808	0.15	62,028,021	0.12	62,028,021	0.12	61,919,898	-0.06
Richmond County	158,434,499	158,492,168	0.04	158,490,990	0.04	158,486,045	0.03	158,473,328	0.02	158,473,328	0.02	158,414,924	-0.01
Total School District	356,714,103	357,479,964	0.21	357,464,301	0.21	357,398,423	0.19	357,229,183	0.14	357,229,183	0.14	356,454,268	-0.07
Expenditures													

Source: Census 1973a; Census 1977a, Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR ESC 1991a; SR DOE 1995a; SR School 1992a.

TABLE D.3-84A.—Changes in School District Total Revenues and Expenditures Over/Under No Action at Full Operation (2010) from Accelerator Production of Tritium Power Plant and Multipurpose Reactor Upgrade and Phaseout for Savannah River Site Region of Influence

Jurisdiction	No Action (\$)	APT with Gas Plant	Change (percent)	Triple Play MHTGR	Change (percent)
Revenues					
Aiken County	107,304,188	107,858,404	0.24	109,143,941	1.71
Barnwell County #19	5,627,386	5,645,012	0.29	5,685,919	0.29
Barnwell County #29	4,526,886	4,535,436	0.09	4,555,280	0.63
Barnwell County #45	12,213,030	12,264,693	0.20	12,384,591	1.4
Columbia County	55,269,463	55,343,025	0.06	55,514,102	0.44
Richmond County	159,553,179	159,669,989	0.03	159,940,589	0.24
Total School District Revenues	344,494,131	345,316,560	0.11	347,224,423	0.79
Expenditures					
Aiken County	112,875,249	113,366,217	0.21	114,505,046	1.44
Barnwell County #19	5,764,535	5,788,415	0.2	5,843,834	1.38
Barnwell County #29	4,629,708	4,648,978	0.2	4,693,699	1.38
Barnwell County #45	13,053,960	13,096,860	0.16	13,196,423	1.09
Columbia County	61,956,151	62,058,088	0.08	62,295,150	0.55
Richmond County	158,434,499	158,489,856	0.02	158,618,095	0.12
Total School District Expenditures	356,714,103	357,448,414	0.1	359,152,247	0.68

Source: Census 1973a; Census 1977a, Census 1983a; DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a; SR ESC 1991a; SR DOE 1995a; SR School 1992a.

APPENDIX E

Appendix E

Appendix E

APPENDIX E: HUMAN HEALTH

E.1 INTRODUCTION

Detailed information on the potential impacts to humans from the normal operational releases of radioactivity and hazardous chemicals from the tritium supply technologies and recycling facilities is presented in this appendix. This information is intended to support assessments of normal operation for the tritium supply and recycling facilities described in sections 4.2.3.9, 4.3.3.9, 4.4.3.9, 4.5.3.9, and 4.6.3.9 of this Programmatic Environmental Impact Statement (PEIS). Section E.2 provides information on radiological impacts while section E.3 provides information on hazardous chemical impacts.

E.2 RADIOLOGICAL IMPACTS TO HUMAN HEALTH

Section E.2 presents supporting information on the potential radiological impacts of normal operation to humans. This section provides the reader with background information on the nature of radiation (section E.2.1), the methodology used to calculate radiological impacts (section E.2.2), radiological releases from tritium supply and recycling facilities (section E.2.3), and radiological impacts from various tritium supply technologies and recycling facilities at each site (sections E.2.4 through E.2.8).

E.2.1 Background

E.2.1.1 *Nature of Radiation and Its Effects on Humans*

What is Radiation? Humans are constantly exposed to radiation from the solar system and from the earth's rocks and soil. This radiation contributes to the natural background radiation that has always surrounded us. But there are also manmade sources of radiation, such as medical and dental x-rays, household smoke detectors, and materials released from nuclear and coal-fired powerplants.

All matter in the universe is composed of atoms, and radiation comes from the activity of these tiny

particles. Atoms are made up of even smaller particles (protons, neutrons, and electrons). The number and arrangement of these particles distinguishes one atom from another.

Atoms of different types are known as elements. There are over 100 natural and manmade elements. Some of these elements, such as uranium, radium, plutonium, and thorium, share a very important quality: they are unstable. As they change into more stable forms, invisible waves of energy or particles, known as ionizing radiation, are released. Radioactivity is the emitting of this radiation.

Ionizing radiation refers to the fact that this energy force can ionize, or electrically charge atoms by stripping off electrons. Ionizing radiation can cause a change in the chemical composition of many things, including living tissue (organs), which can affect the way they function.

The effects on people of radiation that is emitted during disintegration (decay) of a radioactive substance depends on the kind of radiation (alpha and beta particles, and gamma and x-rays) and the total amount of radiation energy absorbed by the body. Alpha particles are the heaviest of these direct types of ionizing radiation, and despite a speed of about 10,000 miles per second, they can travel only a few inches in the air. Alpha particles lose their energy almost as soon as they collide with anything. They can easily be stopped by a sheet of paper or the skin's surface.

Beta particles are much lighter than alpha particles. They can travel as much as 100,000 miles per second and can travel in the air for a distance of about 10 feet. Beta particles can pass through a sheet of paper but may be stopped by a thin sheet of aluminum foil or glass.

Gamma and x-rays, unlike alpha or beta particles, are waves of pure energy. Gamma rays travel at the speed of light (186,000 miles per second). Gamma radiation is very penetrating and requires a thick wall of concrete, lead, or steel to stop it.

The neutron is another particle that contributes to radiation exposure, both directly and indirectly. Indirect exposure is associated with the gamma rays and alpha particles that are emitted following neutron capture in matter. A neutron has about one quarter the weight of an alpha particle and can travel at speeds of up to 24,000 miles per second. Neutrons are more penetrating than beta particles, but less than gamma rays.

The radioactivity of a material decreases with time. The time it takes a material to lose half of its original radioactivity is its half-life. For example, a quantity of iodine-131, a material that has a half-life of 8 days, will lose half of its radioactivity in that amount of time. In 8 more days, one-half of the remaining radioactivity will be lost, and so on. Eventually, the radioactivity will essentially disappear. Each radioactive element has a characteristic half-life. The half-lives of various radioactive elements may vary from millionths of a second to millions of years.

As a radioactive element gives up its radioactivity, it often changes to an entirely different element, one that may or may not be radioactive. Eventually, a stable element is formed. This transformation may take place in several steps and is known as a decay chain. Radium, for example, is a naturally occurring radioactive element with a half-life of 1,622 years. It emits an alpha particle and becomes radon, a radioactive gas with a half-life of only 3.8 days. Radon decays to polonium and, through a series of steps, to bismuth and ultimately to lead.

Units of Radiation Measure. Scientists and engineers use a variety of units to measure radiation. These different units can be used to determine the amount, type and intensity of radiation. Just as heat can be measured in terms of its intensity or its effects using units of calories or degrees, amounts of radiation can be measured in curies, rads, or rems.

The curie, named after the French scientists Marie and Pierre Curie, describes the "intensity" of a sample of radioactive material. The rate of decay of 1 gram of radium is the basis of this unit of measure. It is equal to 3.7×10^{10} disintegrations (decays) per second.

The total energy absorbed per unit quantity of tissue is referred to as absorbed dose. The rad is the unit of

measurement for the physical absorption of radiation. Much like sunlight heats the pavement by giving up an amount of energy to it, radiation gives up rads of energy to objects in its path. One rad is equal to the amount of radiation that leads to the deposition of 0.01 joule of energy per kilogram of absorbing material.

A rem is a measurement of the dose from radiation based on its biological effects. The rem is used to measure the effects of radiation on the body, much like degrees Celsius can be used to measure the effects of sunlight heating pavement. Thus, 1 rem of one type of radiation is presumed to have the same biological effects as 1 rem of any other type of radiation. This standard allows comparison of the biological effects of radionuclides that emit different types of radiation.

An individual may be exposed to ionizing radiation externally from a radioactive source outside the body and/or internally from ingesting radioactive material. The external dose is different from the internal dose. An external dose is delivered only during the actual time of exposure to the external radiation source. An internal dose, however, continues to be delivered as long as the radioactive source is in the body, although both radioactive decay and elimination of the radionuclide by ordinary metabolic processes decrease the dose rate with the passage of time. The dose from internal exposure is calculated over 50 years following the initial exposure.

The three types of doses calculated in this PEIS include an external dose, an internal dose, and a combined external and internal dose. Each type of dose is discussed below.

External Dose. The external dose can arise from several different pathways. All these pathways have in common the fact that the radiation causing the exposure is external to the body. In this PEIS, these pathways include exposure to a cloud of radiation passing over the receptor, standing on ground that is contaminated with radioactivity, swimming in contaminated water, and boating in contaminated water. The appropriate measure of dose is called the effective dose equivalent. It should be noted that if the receptor departs from the source of radiation exposure, his dose rate will be reduced. It is assumed

that external exposure occurs uniformly during the year.

Internal Dose. The internal dose arises from a radiation source entering the human body through either ingestion of contaminated food and water or inhalation of contaminated air. In this PEIS, pathways for internal exposure include ingestion of crops contaminated either by airborne radiation depositing on the crops or by irrigation of crops using contaminated water sources, ingestion of animal products from animals that ingested contaminated food, ingestion of contaminated water, inhalation of contaminated air, and absorption of contaminated water through the skin during swimming. Unlike external exposures, once the radiation enters the body, it remains there for various periods of time depending on decay and biological elimination rates. The unit of measure for internal doses is the committed dose equivalent. It is the internal dose that each body organ receives from 1 "year intake" (ingestion plus inhalation). Normally, a 50- or 70-year dose-commitment period is used (i.e., the 1-year intake period plus 49 or 69 years). The dose rate increases during the 1 year of intake. The dose rate, after the one year of intake, slowly declines as the radioactivity in the body continues to produce a dose. The integral of the dose rate over the 50 or 70 years gives the committed dose equivalent. In this PEIS, a 50-year dose-commitment period was used.

The various organs of the body have different susceptibilities to harm from radiation. The quantity that takes these different susceptibilities into account to provide a broad indicator of the risk to the health of an individual from radiation is called the committed effective dose equivalent. It is obtained by multiplying the committed dose equivalent in each major organ or tissue by a weighting factor associated with the risk susceptibility of the tissue or organ, then summing the totals. It is possible that the committed dose equivalent to an organ is larger than the committed effective dose equivalent if that organ has a small weighting factor. The concept of committed effective dose equivalent applies only to internal pathways.

Differences in radionuclide characteristics lead to different internal doses. For example, for the same amount of radioactivity, in curies, taken into the body, the dose from tritium is much less than from

uranium or plutonium. Tritium emits a weak beta particle and is biologically eliminated from the body over several weeks. Uranium and plutonium emit relatively high-energy alpha particles and are retained in the body for periods of several months to many years.

Combined External and Internal Dose. For convenience, the sum of the committed effective dose equivalent from internal pathways and the effective dose equivalent from external pathways is also called the committed effective dose equivalent in this PEIS (note that in DOE Order 5400.5 this quantity is called the effective dose equivalent).

The units used in this PEIS for committed dose equivalent, effective dose equivalent, and committed effective dose equivalent to an individual are the rem and mrem (1/1000 of 1 rem). The corresponding unit for the collective dose to a population (the sum of the doses to members of the population, or the product of the number of exposed individuals and their average dose) is the person-rem.

Sources of Radiation. The average American receives a total of about 350 mrem per year from all sources of radiation, both natural and manmade. The sources of radiation can be divided into six different categories: cosmic radiation, terrestrial radiation, internal radiation, consumer products, medical diagnosis and therapy, and other sources. Each category is discussed below.

Cosmic radiation is ionizing radiation resulting from energetic charged particles from space continuously hitting the earth's atmosphere. These particles and the secondary particles and photons they create are cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level. For the sites considered in this PEIS, the cosmic radiation ranged from about 30 to 50 mrem per year. The average annual dose to the people in the United States is about 27 mrem.

External terrestrial radiation is the radiation emitted from the radioactive materials in the earth's rocks and soils. The average annual dose from external terrestrial radiation is about 28 mrem. The external terrestrial radiation for the sites in this PEIS ranged from about 30 to 75 mrem per year.

Internal radiation arises from the human body metabolizing natural radioactive material that has entered the body by inhalation or ingestion. Natural radionuclides in the body include isotopes of uranium, thorium, radium, radon, polonium, bismuth, potassium, rubidium, and carbon. The major contributors to the annual dose equivalent for internal radioactivity are the short-lived decay products of radon which contribute about 200 mrem per year. The average dose from other internal radionuclides is about 39 mrem per year.

Consumer products also contain sources of ionizing radiation. In some products, like smoke detectors and airport x-ray machines, the radiation source is essential to the products' operation. In other products, such as television and tobacco, the radiation occurs incidentally to the product function. The average annual dose is about 10 mrem.

Radiation is an important diagnostic medical tool and cancer treatment. Diagnostic x-rays result in an average annual exposure of 39 mrem. Nuclear medical procedures result in an average annual exposure of 14 mrem.

There are a few additional sources of radiation that contribute minor doses to individuals in the United States. The dose from nuclear fuel cycle facilities, such as uranium mines, mills and fuel processing plants, nuclear power plants, and transportation routes has been estimated to be less than 1 mrem per year. Radioactive fallout from atmospheric atomic bomb tests, emissions of radioactive material from Department of Energy (DOE) facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials contributes less than 1 mrem per year to the average dose to an individual. Air travel contributes approximately 1 mrem per year to the average dose.

The collective (or population) dose to an exposed population is calculated by summing the estimated doses received by each member of the exposed population. This total dose received by the exposed population is measured in person-rem. For example, if 1,000 people each received a dose of 1 millirem (0.001 rem), the collective dose is (1,000 persons x 0.001 rem = 1.0 person-rem). Alternatively, the same collective dose (1.0 person-rem) results from 500 people each of whom received a dose of

2 millirem (500 persons x 2 millirem = 1 person-rem).

Limits of Radiation Exposure. The amount of manmade radiation that the public may be exposed to is limited by Federal regulations. Although most scientists believe that radiation absorbed in small doses over several years is not harmful, U.S. Government regulations assume that the effects of all radiation exposures are cumulative.

The exposure to a member of the general public from DOE facility releases into the atmosphere is limited by the Environmental Protection Agency (EPA) to an annual dose of 10 mrem, in addition to the natural background and medical radiation normally received (40 CFR 61, Subpart H). DOE also limits to 10 mrem, the dose annually received from material released into the atmosphere (DOE Order 5400.5). EPA and DOE also limit the annual dose to the general public from radioactive releases to drinking water to 4 mrem (40 CFR 141; DOE Order 5400.5). The annual dose from all radiation sources from a site is limited by the EPA to 25 mrem (40 CFR 190). The DOE annual limit of radiation dose to a member of the general public from all DOE facilities is 100 mrem total from all pathways (DOE Order 5400.5). For people working in an occupation that involves radiation, DOE and the Nuclear Regulatory Commission (NRC) limit doses to 5 rem (5,000 mrem) in any one year (10 CFR 20; 10 CFR 835).

E.2.1.2 Health Effects

Radiation exposure and its consequences are topics of interest to the general public. For this reason, this PEIS places much emphasis on the consequences of exposure to radiation, even though the effects of radiation exposure under most circumstances evaluated in this PEIS are small. This section explains the basic concepts used in the evaluation of radiation effects in order to provide the background for later discussion of impacts.

Radiation can cause a variety of ill-health effects in people. The most significant ill-health effect to depict the consequences of environmental and occupational radiation exposure is induction of cancer fatalities. This effect is referred to as "latent" cancer fatalities because the cancer may take many years to

develop and for death to occur and may not actually be the cause of death. In the discussions that follow, it should be noted that all fatal cancers are latent and the term "latent" is not used.

Health impacts from radiation exposure, whether from sources external or internal to the body, generally are identified as "somatic" (affecting the individual exposed) or "genetic" (affecting descendants of the exposed individual). Radiation is more likely to produce somatic effects rather than genetic effects. Therefore, for this PEIS, only the somatic risks are presented. The somatic risks of most importance are the induction of cancers. Except for leukemia, which can have an induction period (time between exposure to carcinogen and cancer diagnosis) of as little as 2 to 7 years, most cancers have an induction period of more than 20 years.

For a uniform irradiation of the body, the incidence of cancer varies among organs and tissues; the thyroid and skin demonstrate a greater sensitivity than other organs. However, such cancers also produce relatively low mortality rates because they are relatively amenable to medical treatment. Because of the readily available data for cancer mortality rates and the relative scarcity of prospective epidemiologic studies, somatic effects leading to cancer fatalities rather than cancer incidence are presented in this PEIS. The numbers of cancer fatalities can be used to compare the risks among the various alternatives.

The fatal cancer risk estimators presented in this appendix for radiation technically apply only to low-Linear Energy Transfer radiation (gamma rays and beta particles). However, on a per rem rather than a per rad basis, the fatal risk estimators are higher for this type of radiation than for high-Linear Energy Transfer radiation (alpha particles). In this PEIS, the low-Linear Energy Transfer risk estimators are conservatively assumed to apply to all radiation exposures.

The National Research Council's Committee on the Biological Effects of Ionizing Radiations has prepared a series of reports to advise the U.S. Government on the health consequences of radiation exposures. The latest of these reports, *Health Effects of Exposure to Low Levels of Ionizing Radiation BEIR V*, published in 1990, provides the most current estimates for excess mortality from leukemia and

cancers other than leukemia expected to result from exposure to ionizing radiation. The BEIR V report updates the models and risk estimates provided in the earlier report of the BEIR III Committee, *The Effects of Populations of Exposure to Low Levels of Ionizing Radiation*, published in 1980. BEIR V models were developed for application to the U.S. population.

BEIR V provides estimates that are consistently higher than those in BEIR III. This is attributed to several factors, including the use of a linear dose response model for cancers other than leukemia, revised dosimetry for the Japanese atomic bomb survivors, and additional follow up studies of the atomic bomb survivors and other cohorts. BEIR III employs constant relative and absolute risk models, with separate coefficients for each sex and several age-at-exposure groups, while BEIR V develops models in which the excess relative risk is expressed as a function of age at exposure, time after exposure, and sex for each of several cancer categories. BEIR III models were based on the assumption that absolute risks are comparable between the atomic bomb survivors and the U.S. population, while BEIR V models were based on the assumption that the relative risks are comparable. For a disease such as lung cancer, where baseline risks in the United States are much larger than those in Japan, the BEIR V approach leads to larger risk estimates than the BEIR III approach.

The models and risk coefficients in BEIR V were derived through analyses of relevant epidemiologic data including the Japanese atomic bomb survivors, ankylosis spondylitis patients, Canadian and Massachusetts fluoroscopy patients (breast cancer), New York postpartum mastitis patients (breast cancer), Israel tinea capitis patients (thyroid cancer), and Rochester thymus patients (thyroid cancer). Models for leukemia, respiratory cancer, digestive cancer, and other cancers used only the atomic bomb survivor data, although results of analyses of the ankylosis spondylitis patients were considered. Atomic bomb survivor analyses were based on revised dosimetry with an assumed Relative Biological Effectiveness of 20 for neutrons and were restricted to doses of less than 400 rads. Estimates of risks of fatal cancers other than leukemia were obtained by totaling the estimates for breast cancer, respiratory cancer, digestive cancer, and other cancers.

Risk Estimates for Doses Received During an Accident. BEIR V includes risk estimates for a single exposure of 10 rem to a population of 100,000 people (10^6 person-rem). In this case, fatality estimates for leukemia, breast cancer, respiratory cancer, digestive cancer, and other cancers are given for both sexes and nine age-at-exposure groups. These estimates, based on the linear model, are summarized in table E.2.1.2-1. The average risk estimate from all ages and both sexes is 885 excess cancer fatalities per million person-rem. This value has been conservatively rounded up to 1,000 excess cancer fatalities per million person-rem.

Although values for other health effects are not presented in this PEIS, the risk estimators for non-fatal cancers and for genetic disorders to future generations are estimated to be approximately 200 and 260 per million person-rem, respectively. These values are based on information presented in ICRP Publication 60 and are seen to be 20 percent and 26 percent, respectively, of the fatal cancer estimator. Thus, for example, if the number of excess fatal cancers is projected to be "x," the number of excess genetic disorders would be 0.26 times "x."

Risk Estimates for Doses Received During Normal Operation. For low doses and dose rates, a linear-quadratic model was found to provide a significantly better fit to the data for leukemia than a linear one, and leukemia risks were based on a linear-quadratic function. This reduces the effects by a factor of two over estimates that are obtained from the linear model. For other cancers, linear models

were found to provide an adequate fit to the data, and were used for extrapolation to low doses. However, the BEIR V Committee recommended reducing these linear estimates by a factor between 2 and 10 for doses received at low dose rates. For this PEIS, a risk reduction factor of two was adopted for conservatism.

Based on the above discussion, the resulting risk estimator would be equal to half the value observed for accident situations or approximately 500 excess fatal cancer per million person-rem (0.0005 excess fatal cancer per person-rem). This is the risk value used in this PEIS to calculate fatal cancers to the general public during normal operations. For workers, a value of 400 excess fatal cancers per million person-rem (0.0004 excess fatal cancer per person-rem) is used in this PEIS. This lower value reflects the absence of children in the workforce. Again, based on information provided in ICRP Publication 60, the health risk estimators for nonfatal cancers and genetic disorders among the public are 20 percent and 26 percent, respectively, of the fatal cancer risk estimator. For workers they are both 20 percent of the fatal cancer risk estimator. For this PEIS, only fatal cancers are presented.

The risk estimates may be applied to calculate the effects of exposing a population to radiation. For example, in a population of 100,000 people exposed only to natural background radiation (0.3 rem per year), 15 latent cancer fatalities per year would be inferred to be caused by the radiation ($100,000 \text{ persons} \times 0.3 \text{ rem per year} \times 0.0005 \text{ latent cancer fatalities per person-rem} = 15 \text{ latent cancer fatalities per year}$).

Sometimes, calculations of the number of excess cancer fatalities associated with radiation exposure do not yield whole numbers and, especially in environmental applications, may yield numbers less than 1.0. For example, if a population of 100,000 were exposed as above, but to a total dose of only 0.001 rem, the collective dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.05 ($100,000 \text{ persons} \times 0.001 \text{ rem} \times 0.0005 \text{ latent cancer fatalities/person-rem} = 0.05 \text{ latent fatal cancers}$).

How should one interpret a nonintegral number of latent cancer fatalities such as 0.05? The answer is to

TABLE E.2.1.2-1.—Lifetime Risks per 100,000 Persons Exposed to a Single Exposure of 10 Rem

Gender	Type of Fatal Cancer		
	Leukemia ^a	Cancers Other Than Leukemia	Total Cancers
Male	220	660	880
Female	160	730	890
Average	190	695	885 ^b

^a These are the linear estimates, and are double the linear-quadratic estimates provided in BEIR V for leukemia at low doses and dose-rates.

^b This value has been rounded up to 1,000 excess cancer fatalities per million person-rem.

NAS 1990a.

interpret the result as a statistical estimate. That is, 0.05 is the *average* number of deaths that would result if the same exposure situation were applied to many different groups of 100,000 people. In most groups, no person (0 people) would incur a latent cancer fatality from the 0.001 rem dose each member would have received. In a small fraction of the groups, 1 latent fatal cancer would result; in exceptionally few groups, 2 or more latent fatal cancers would occur. The *average* number of deaths over all the groups would be 0.05 latent fatal cancers (just as the average of 0, 0, 0, and 1 is 1/4, or 0.25). The most likely outcome is 0 latent cancer fatalities.

These same concepts apply to estimating the effects of radiation exposure on a single individual. Consider the effects, for example, of exposure to background radiation over a lifetime. The "number of latent cancer fatalities" corresponding to a single individual's exposure over a (presumed) 72-year lifetime to 0.3 rem per year is the following:

$$\begin{aligned} &1 \text{ person} \times 0.3 \text{ rem per year} \times 72 \text{ years} \times \\ &0.0005 \text{ latent cancer fatalities per person-} \\ &\text{rem} = 0.011 \text{ latent cancer fatalities.} \end{aligned}$$

Again, this should be interpreted in a statistical sense; that is, the estimated effect of background radiation exposure on the exposed individual would produce a 1.1-percent chance that the individual might incur a latent fatal cancer caused by the exposure. Presented another way, this method estimates that approximately 1.1 percent of the population might die of cancers induced by the radiation background.

E.2.2 Methodology for Estimating Radiological Impacts of Normal Operation

The radiological impacts of normal operation of reactors and support facilities were calculated using Version 1.485 of the GENII computer code. Site-specific and technology-specific input data were used, including location, meteorology, population, food production and consumption, and source terms. The GENII code was used for analysis of normal operations and design basis accidents. Section E.2.2.1 briefly describes GENII and outlines the approach used for normal operations. The approach used for design basis accidents is discussed in appendix F.

E.2.2.1 GENII Computer Code

The GENII computer model, developed by Pacific Northwest Laboratory for the U.S. Department of Energy, is an integrated system of various computer modules that analyze environmental contamination resulting from acute or chronic releases to, or initial contamination in, air, water, or soil. The model calculates radiation doses to individuals and populations. The GENII computer model is well documented for assumptions, technical approach, methodology, and quality assurance issues (*GENII - The Hanford Environmental Radiation Dosimetry Software System* (December 1988)). The GENII computer model has gone through extensive quality assurance and quality control steps. These include the comparison of results from model computations against those from hand calculations, and the performance of internal and external peer reviews. Recommendations given in these reports were incorporated into the final GENII computer model, as deemed appropriate.

For this PEIS only the ENVIN, ENV, and DOSE computer modules were used. The codes are connected through data transfer files. The output of one code is stored in a file that can be used by the next code in the system. In addition, a computer code called CREGENII was prepared to aid the user with the preparation of input files into GENII.

CREGENII. The CREGENII code helps the user, through a series of interactive menus and questions, prepare a text input file for the environmental dosimetry programs. In addition, CREGENII prepares a batch processing file to manage the file handling needed to control the operations of subsequent codes and to prepare an output report.

ENVIN. The ENVIN module of the GENII code controls the reading of the input files prepared by CREGENII and organizes the input for optimal use in the environmental transport and exposure module, ENV. The ENVIN code interprets the basic input, reads the basic GENII data libraries and other optional input files, and organizes the input into sequential segments on the basis of radionuclide decay chains.

A standardized file that contains scenario, control, and inventory parameters is used as input to ENVIN.

Radionuclide inventories can be entered as functions of releases to air or water, concentrations in basic environmental media (air, soil, or water), or concentrations in foods. If certain atmospheric dispersion options have been selected, this module can generate tables of atmospheric dispersion parameters that will be used in later calculations. If the finite plume air submersion option is requested in addition to the atmospheric dispersion calculations, preliminary energy-dependent finite plume dose factors also are prepared. The ENVIN module prepares the data transfer files that are used as input by the ENV module; ENVIN generates the first portion of the calculation documentation—the run input parameters report.

ENV. The ENV module calculates the environmental transfer, uptake, and human exposure to radionuclides that result from the chosen scenario for the user-specified source term. The code reads the input files from ENVIN and then, for each radionuclide chain, sequentially performs the precalculations to establish the conditions at the start of the exposure scenario. Environmental concentrations of radionuclides are established at the beginning of the scenario by assuming decay of preexisting sources, considering biotic transport of existing subsurface contamination, and defining soil contamination from continuing atmospheric or irrigation depositions. Then, for each year of postulated exposure, the code estimates air, surface soil, deep soil, groundwater, and surface water concentrations of each radionuclide in the chain. Human exposures and intakes of each radionuclide are calculated for: 1) pathways of external exposure from finite atmospheric plumes, 2) inhalation, 3) external exposure from contaminated soil, sediments, and water, 4) external exposure from special geometries, and 5) internal exposures from consumption of terrestrial foods, aquatic foods, drinking water, animal products, and inadvertent intake of soil. The intermediate information on annual media concentrations and intake rates are written to data transfer files. Although these may be accessed directly, they are usually used as input to the DOSE module of GENII.

GENII is a general purpose computer code used to model dispersion, transport, and long-term exposure effects of specific radionuclides and pathways. Sophisticated codes such as UFOTRI and ETMOD (Environmental Tritium Model) are used exclusively

for modeling tritium transport and dosimetry. The UFOTRI and ETMOD codes were not chosen for use in this PEIS because of the lack of information on detailed facility design and on the breakdown of tritium into elemental and tritiated water forms, and because these codes cannot be used for modeling the exposure effects of radionuclides other than tritium. GENII was chosen because it can model both air and surface transport pathways and is not restricted to any radionuclides.

DOSE. The DOSE module reads the annual intake and exposure rates defined by the ENV module and converts the data to radiation dose. External dose is calculated with precalculated factors from the EXTDF module or from a data file prepared outside of GENII. Internal dose is calculated with precalculated factors from the INTDF module.

EXTDF. The EXTDF module calculates the external dose-rate factors for submersion in an infinite cloud of radioactive materials, immersion in contaminated water, and direct exposure to plane or slab sources of radionuclides. EXTDF was not used. Instead, the dose rate factors listed in *External Dose Rate Factors for Calculation of Dose to the Public* (DOE/EH-0070) were used for this PEIS.

INTDF. Using the *Limits for Intakes of Radionuclides by Workers* (ICRP Publication 30) model, the INTDF module calculates the internal (inhalation and ingestion) dose conversion factors of radionuclides for specific organs. The factors generated by INTDF were used for the calculations presented in this PEIS.

E.2.2.2 Data and Assumptions

In order to perform the dose assessments for this PEIS, different types of data must be collected and/or generated. In addition, calculational assumptions have to be made. This section discusses the data collected and/or generated for use in the dose assessment and assumptions made for this PEIS.

Meteorological Data. The meteorological data used for all 5 sites were in the form of joint frequency data files. A joint frequency data file is a table listing the fractions of time the wind blows in a certain direction, at a certain speed, and within a certain stability class. The joint frequency data files were based on

measurements over a 1-year period at various locations and at different heights at the sites. Average meteorological conditions (averaged over the 1-year period) were used for normal operation. For use in design basis accidents, the 50 percentile option was used. Meteorological data are presented in *Health Risk Data* (HNUS 1995a).

Population Data. Population distributions were based on *1990 Census of Population and Housing* data. Projections were determined for the years 2010, 2030, and 2050 for areas within 80 kilometers of the proposed facilities at each candidate site. These years of analysis were selected as representative of the start of operations at tritium supply and recycling facilities, the midplant-life phase, and the end of plant-life phase, respectively. The population was spatially distributed on a circular grid with 16 directions and 10 radial distances up to 80 kilometers. The grid was centered on the facility from which the radionuclides were assumed to be released. Population data are presented in *Health Risk Data* (HNUS 1995a). The site population at the midlife of operation (2030) was assumed to be representative of the population over the 40-year operational period and was used in the impact assessments.

Source Term Data. The source terms (quantities of radionuclides released into the environment over a given period) were estimated on the basis of latest conceptual designs of facilities and experience with similar facilities. The source terms used to generate the estimated impacts of normal operation are provided in section E.2.3 for the tritium supply technologies and recycling facilities which could be located at any of the five sites. Source terms for site dependent facilities are presented in sections E.2.3.2 through E.2.3.6.

Food Production and Consumption Data. Data from the *1987 Census of Agriculture* were used to generate site-specific data for food production. Food production was spatially distributed on the same circular grid as was used for the population distributions. The consumption rates were those used in GENII for the maximum individual and average individual. People living within the 80 kilometer assessment area were assumed to consume only food grown in that area.

Calculational Assumptions. Dose assessments were performed for members of the general public and workers. Dose assessments for members of the public were performed for two different types of receptors considered in this PEIS: a maximally exposed offsite individual and the general population living within 50 miles of the facility. It was assumed that the maximally exposed individual was located at a position on the site boundary that would yield the highest impacts during normal operation of a given alternative. If more than one facility was assumed operating at a site, the dose to this individual from each facility was calculated. The doses were then summed to give the total dose to this individual. A 50-mile population dose was calculated for each operating facility at a site. These doses were then added to give the total population dose at that site.

To estimate the radiological impacts from normal operation of reactors and support facilities, additional assumptions and factors were considered in using GENII, as follows:

- No prior deposition of radionuclides on ground surfaces was assumed.
- For the maximally exposed offsite individual, the annual exposure time to the plume and to soil contamination was 0.7 years (NRC 1977b).
- For the population, the annual exposure time to the plume and to soil contamination was 0.5 years (NRC 1977b).
- A semi-infinite/finite plume model was used for air immersion doses. Other pathways evaluated were ground exposure, inhalation, ingestion of food crops and animal products contaminated by either deposition of radioactivity from the air or irrigation, ingestion of fish and other aquatic food raised in contaminated water, swimming and boating in contaminated surface water, and drinking contaminated water. It should be noted that not all pathways were available at every site.
- For atmospheric releases it was assumed that ground level releases would occur for

all tritium supply and recycling facilities. For site-dependent facilities, reported release heights were used and assumed to be the effective stack height. Use of the effective stack height negates plume rise thereby making the resultant doses conservative.

- The calculated doses were 50-year committed doses from 1 year of intake.
- Resuspension of particulates was not considered because prior calculations of dust loading in the atmosphere showed that this pathway was negligible compared with others.

The exposure, uptake, and usage parameters used in the GENII model are provided in tables E.2.2.2-1 through E.2.2.2-4.

Annual average doses to workers for No Action at Idaho National Engineering Laboratory (INEL), Nevada Test Site (NTS), and Pantex Plant (Pantex) were based on measured values received by radiation workers during the 1989 to 1992 time period. The average dose received by a worker at these sites in 2010 was assumed to remain the same as the annual average during the 1989 to 1992 period. The total workforce dose in 2010 was calculated by multiplying the average worker dose by the projected number of workers in 2010. For ORR and SRS, worker dose projections provided by the sites were used.

Doses to workers directly associated with tritium supply technologies and recycling facilities were taken from the reports prepared by Fluor Daniel, Inc., and Sandia National Laboratories, New Mexico. To obtain the total workforce dose at a site with a particular tritium supply technology and recycling facilities in operation, the site dose from No Action was added to that from the tritium supply technologies and recycling facilities being evaluated. The average

dose to a site worker was then calculated by dividing this dose by the total number of radiation workers at the site.

All doses to workers include a component associated with the intake of radioactivity into the body and another component resulting from external exposure to direct radiation.

E.2.2.3 Health Effects Calculations

Doses calculated by GENII were used to estimate health effects using the risk estimators presented in section E.2.1.2. The incremental cancer fatalities in the general population and in groups of workers from radiation exposure were therefore estimated by multiplying the collective combined effective dose equivalent by 0.0005 and 0.0004 fatal cancers/person-rem, respectively. In this PEIS, the collective combined effective dose equivalent is the sum of the collective committed effective dose equivalent (internal dose) and the collective effective dose equivalent (external dose), section E.2.1.1.

Although health risk factors are statistical factors and therefore not strictly applicable to individuals, they have been used in the past to estimate the incremental risk to an individual from exposure to radiation. Therefore, the factors of 0.0005 and 0.0004 per rem of individual committed effective dose equivalent for a member of the public and for a worker, respectively, have also been used in this PEIS to calculate the individual's incremental fatal cancer risk from exposure to radiation.

For the public, the health effects expressed in this PEIS are the risk of fatal cancers to the maximally exposed individual and the number of fatal cancers to the 50-mile population from exposure to radioactivity released from any site over the 40-year operational period. For workers, the health effects expressed are the risk to the average worker at a site and the number of fatal cancers to all workers at that site from 40 years of site operations.

TABLE E.2.2.2-1.—*GENII Exposure Parameters to Plumes and Soil Contamination*

Maximal Individual			General Population		
External Exposure (hours)	Inhalation of Plume	External Exposure (hours)	Inhalation of Plume	External Exposure (hours)	Inhalation of Plume
Plume	Soil Contamination	Exposure Time (hours)	Breathing Rate (cc/sec)	Plume	Soil Contamination
6,136	6,136	6,136	270	4,383	4,383
				4,383	270

Source: HNUS 1995a.

TABLE E.2.2.2-2.—*GENII Usage Parameters for Consumption of Terrestrial Food*

Maximum Individual						General Population			
Food Type	Growing Time (days)	Yield (kg/m ²)	Holdup Time (days)	Consumption Rate (kg/yr)	Growing Time (days)	Yield (kg/m ²)	Holdup Time (days)	Consumption Rate (kg/yr)	
Leafy Vegetables	90	1.5	1	30	90	1.5	14	15	
Root Vegetables	90	4	5	220	90	4	14	140	
Fruit	90	2	5	330	90	2	14	64	
Grains/Cereals	90	0.8	180	80	90	0.8	180	72	

Source: HNUS 1995a.

TABLE E.2.2.2-3.—GENII Usage Parameters for Consumption of Animal Products

Food Type	Stored Feed				Fresh Forage					
	Consumption Rate (kg/yr)	Holdup Time (days)	Diet Fraction	Growing Time (days)	Yield (kg/m ³)	Storage Time (days)	Diet Fraction	Growing Time (days)	Yield (kg/m ³)	Storage Time (days)
Maximum Individual										
Beef	80	15	0.25	90	0.8	180	0.75	45	2	100
Poultry	18	1	1	90	0.8	180				
Milk	270	1	0.25	45	2	100	0.75	30	1.5	0
Eggs	30	1	1	90	0.8	180				
General Population										
Beef	70	34	0.25	90	0.8	180	0.75	45	2	100
Poultry	8.5	34	1	90	0.8	180				
Milk	230	4	0.25	45	2	100	0.75	30	1.5	0
Eggs	20	18	1	90	0.8	180				

Source: HNUS 1995a.

TABLE E.2.2.2-4.—GENII Usage Parameters for Aquatic Activities

Activity	Maximum Individual			General Population		
	Transit Time to Usage Point (days)	Holdup Time (days)	Usage Rate (per year)	Transit Time to Usage Point (days)	Holdup Time (days)	Usage Rate
Drinking Water	0	0	730 liters	0	0	Site dependent
Swimming	0	0	100 hours	0	0	Site dependent
Boating	0	0	100 hours	0	0	Site dependent
Shoreline	0	0	500 hours	0	0	Site dependent
Ingestion of Fish	0	0	40 kg	0	0	Site dependent
Ingestion of Mollus	0	0	6.9 kg	0	0	Site dependent
Ingestion of Crusta	0	0	6.9 kg	0	0	Site dependent
Ingestion of Plants	0	0	6.9 kg	0	0	Site dependent

Source: HNUS 1995a.

Source: HNUS 1995a.

E.2.3 New Tritium Supply and Recycling Facilities Information

This section presents source terms and descriptions of radiological releases to the environment from the normal operation of tritium supply and recycling facilities at Idaho National Engineering Laboratory (INEL), Nevada Test Site (NTS), the Oak Ridge Reservation (ORR), Pantex Plant (Pantex), and the Savannah River Site (SRS). In-plant worker doses are also presented.

Manufacturing and processing of tritium for use in nuclear weapons is carried out at tritium supply and recycling facilities. There are four different technologies proposed for the production of tritium considered in this PEIS. These are a Heavy-Water Reactor (HWR), a Modular High Temperature Gas-Cooled Reactor (MHTGR), an Advanced Light Water Reactor (ALWR), and Accelerator Production of Tritium (APT). In addition to the reactors, fuel fabrication facilities for the HWR and MHTGR would need to be built to supply fuel to those two types of reactors. Fuel for the ALWR would be procured commercially. For each technology that is proposed for the production of tritium, a tritium extraction facility is needed to remove tritium from the targets.

The tritium recycling facility could be collocated with the new tritium supply facility or be located at SRS. This facility processes the tritium received from the tritium supply and from the dismantling of nuclear weapons.

For the purposes of this PEIS, the radiological impacts to the public of fuel and target fabrication can be ignored because there are no doses associated with target fabrication and the releases from HWR and MHTGR fuel fabrication are much smaller than

from reactor operations. Because the ALWR fuel would be procured commercially, the radiological impacts to workers and the public associated with fuel preparation would not occur at the reactor site and would have already been addressed in environmental statements or reports for the fuel manufacturer.

The following subsections present the radiological releases from the facilities associated with tritium supply technologies and recycling facilities. The resulting doses to the public are presented in sections E.2.4 through E.2.8 since they are site dependent. However, because worker doses are dependent on the tritium supply alone, they are included in the following paragraphs. Table E.2.3-1 presents the details of the worker impacts for each reactor/accelerator combination.

E.2.3.1 Heavy Water Reactor

The *Data Report on Heavy Water Reactor* (February 1995) describes the HWR considered for this PEIS. Included in the report are the radioactive releases to both the atmosphere and surface water for a "wet" site (ORR and SRS). For a "dry" site (INEL, NTS, and Pantex), it was conservatively assumed that all like radioactive discharges to the surface water at ORR and SRS would be released into the atmosphere. Table E.2.3.1-1 presents these releases.

The doses to the worker population for 1 year of operation of the HWR and all its support facilities was calculated to be 41 person-rem. An estimated additional 0.66 fatal cancers could result from 40 years of operation. The average worker dose and health effects were calculated to be 60 mrem and a risk of fatal cancer of 9.7×10^{-4} from 40 years of operation.

TABLE E.2.3-1.—Estimated Annual In-Plant Worker Doses and Resulting Health Effects
for Various Tritium Supply Technologies and Recycling Facilities

Facility	HWR	MHTGR	ALWR/Large	ALWR/Small	Helium-3 Target System	APT	SILC Target System
Fuel and Target Fabrication							
Number of badged workers	49	49	0	0	0		0
Person-rem	2.7	0.3	0	0	0		0
Average exposure, mrem	55	5	0	0	0		0
Reactor and Tritium Extraction							
Number of badged workers	230	180	210	125	258		258
Person-rem	37	28	170	100	38.3		40.8
Average exposure, mrem	161	156	810	800	148		158
Tritium Recycling							
Number of badged workers	400	400	400	400	400		400
Person-rem	1.6	1.6	1.6	1.6	1.6		1.6
Average exposure, mrem	4	4	4	4	4		4
Totals							
Number of badged workers	679	629	610	525	658		658
Person-rem	41	30	172	102	40		42
Average exposure, mrem	60	48	281	194	61		64
Annual risk of fatal cancer (average worker)	2.4×10^{-5}	1.9×10^{-5}	1.1×10^{-4}	7.8×10^{-5}	2.4×10^{-5}		2.6×10^{-5}
40-year plant life, risk of fatal cancers	9.7×10^{-4}	7.6×10^{-4}	4.5×10^{-3}	3.1×10^{-3}	9.7×10^{-4}		1.0×10^{-3}
Additional fatal cancers annually (all workers)	0.016	0.012	0.069	0.041	0.016		0.017
40-year plant life, additional fatal cancers	0.66	0.48	2.8	1.6	0.64		0.68

Note: SILC - Spallation-induced lithium conversion.

Source: DOE 1995d; DOE 1995f; DOE 1995g; SNL 1995a.

TABLE E.2.3.1-1.—Annual Radioactive Releases During Normal Operation from Heavy Water Reactor (curies)

Isotope	Wet Site Releases		Dry Site Releases	Isotope	Wet Site Releases		Dry Site Releases
	Liquid	Air	Air		Liquid	Air	Air
H-3	1.0×10^3	6.0×10^3	7.0×10^3	Sb-124	1.1×10^{-3}	0	1.1×10^{-3}
C-14	0	7.3	7.3	Sb-125	1.1×10^{-3}	0	1.1×10^{-3}
Na-24	0.075	0	0.075	I-129	7.5×10^{-12}	0	7.5×10^{-12}
P-32	5.9×10^{-6}	0	5.9×10^{-6}	I-131	1.8×10^{-3}	8.0×10^{-3}	9.8×10^{-3}
S-35	2.2×10^{-5}	0	2.2×10^{-5}	I-132	1.1×10^{-3}	0	1.1×10^{-3}
Ar-41	0	34	34	I-133	4.2×10^{-3}	0.13	0.13
Cr-51	0.065	0	0.065	I-134	6.7×10^{-4}	0	6.7×10^{-4}
Mn-54	9.3×10^{-6}	0	9.3×10^{-6}	I-135	3.3×10^{-3}	0	3.3×10^{-3}
Fe-59	8.7×10^{-5}	0	8.7×10^{-5}	Xe-133	0	410	410
Co-58	8.0×10^{-4}	0	8.0×10^{-4}	Xe-135m	0	5.5	5.5
Co-60	8.9×10^{-4}	9.6×10^{-5}	9.9×10^{-4}	Xe-135	0	13	13
Zn-65	9.3×10^{-6}	0	9.3×10^{-6}	Cs-134	3.1×10^{-3}	0	3.1×10^{-3}
Kr-85m	0	3.7	3.7	Cs-137	0.061	5.7×10^{-7}	0.061
Kr-85	0	0.8	0.8	Ba-140	3.0×10^{-3}	0	3.0×10^{-3}
Kr-87	0	7.9	7.9	La-140	3.2×10^{-6}	0	3.2×10^{-6}
Kr-88	0	10	10	Ce-141	8.7×10^{-3}	0	8.7×10^{-3}
Sr-89	1.3×10^{-5}	0	1.3×10^{-5}	Ce-143	2.2×10^{-3}	0	2.2×10^{-3}
Sr-90	0.19	4.1×10^{-4}	0.19	Ce-144	6.7×10^{-3}	0	6.7×10^{-3}
Sr-91	2.0×10^{-3}	0	2.0×10^{-3}	Pm-147	6.6×10^{-7}	0	6.6×10^{-7}
Sr-92	7.8×10^{-4}	0	7.8×10^{-4}	U-237	6.3×10^{-5}	0	6.3×10^{-5}
Nb-95	8.6×10^{-6}	0	8.6×10^{-6}	Np-238	3.6×10^{-5}	0	3.6×10^{-5}
Zr-95	0.018	0	0.018	Np-239	0.039	0	0.039
Ru-103	8.8×10^{-4}	0	8.8×10^{-4}	Pu-239	0.012	0	0.012

Source: DOE 1995d.

E.2.3.2 Modular High Temperature Gas-Cooled Reactor

The *Data Report on Modular High Temperature Gas-Cooled Reactor Tritium Supply Plant*, February 1995, describes the MHTGR considered for this PEIS. Included in the report are the radioactive releases into the atmosphere. There are no liquid radioactive releases. Table E.2.3.2-1 presents the atmospheric releases.

The dose to the worker population for 1 year of operation from the MHTGR and all its support facilities was calculated to be 30 person-rem. An additional 0.48 fatal cancers could result from 40 years of operation. The annual average worker dose was calculated to be 48 mrem. A fatal cancer risk of

7.6×10^{-4} could result to this worker from 40 years of operation. These doses and health effects are given in table E.2.3-1.

E.2.3.3 Advanced Light Water Reactor

The *Data Report on Advanced Light Water Reactor Tritium Supply Plant*, February 1995, evaluated the radiological emissions from the production of tritium using four different advanced light water reactors (two Large ALWRs, Advanced Boiling Water Reactor and CE System 80+ reactor, of about 1,100 to 1,300 MWe and two Small ALWRs, Simplified Boiling Water Reactor and AP600, of about 600 MWe). The releases from each are discussed below for both a "dry site" (INEL, NTS, and Pantex) and a "wet site" (ORR and SRS).

TABLE E.2.3.2-1.—Annual Atmospheric Radioactive Releases
from Modular High Temperature Gas-Cooled Reactor (curies)

Isotope	Atmospheric Release	Isotope	Atmospheric Release	Isotope	Atmospheric Release
H-3	2.1×10^3	Mo-99	2.0×10^{-7}	I-132	0.31
Kr-85m	1.8	Tc-99m	1.8×10^{-6}	I-133	0.17
Kr-85	4.1×10^{-3}	Ru-103	8.3×10^{-9}	I-134	0.75
Kr-87	3.8	Ru-105	7.9×10^{-7}	I-135	0.27
Kr-88	5.6	Ru-106	7.9×10^{-11}	Xe-133	0.86
Kr-89	2.1	Rh-105	9.4×10^{-8}	Xe-135	1.8
Kr-90	0.86	Ag-110m	8.6×10^{-13}	Cs-134	1.2×10^{-8}
Rb-86	6.4×10^{-4}	Sb-127	4.5×10^{-9}	Cs-136	3.6×10^{-9}
Sr-89	4.5×10^{-4}	Sb-129	5.6×10^{-6}	Cs-137	4.1×10^{-9}
Sr-90	9.0×10^{-7}	Te-127m	5.6×10^{-5}	Ba-140	3.2×10^{-8}
Sr-91	1.2×10^{-6}	Te-127	1.8×10^{-4}	La-140	3.8×10^{-7}
Y-90	1.1×10^{-8}	Te-129m	4.9×10^{-4}	Ce-141	1.7×10^{-8}
Y-91	9.0×10^{-9}	Te-129	0.068	Ce-143	3.6×10^{-7}
Nb-95	1.6×10^{-8}	Te-131m	7.9×10^{-3}	Ce-144	7.5×10^{-10}
Zr-95	8.6×10^{-9}	Te-132	0.018	Pr-143	3.7×10^{-8}
Zr-97	7.5×10^{-8}	I-131	0.026	Nd-147	1.9×10^{-8}

Source: DOE 1995e.

E.2.3.3.1 Large Advanced Light Water Reactor

Radioactive releases into the atmosphere and surface water for a "wet site" (ORR and SRS) and into the atmosphere for a "dry site" (INEL, NTS, and Pantex) from the Advanced Boiling Water Reactor and CE System 80+ reactor are presented in tables E.2.3.3.1-1 and E.2.3.3.1-2, respectively.

The dose to the worker population for 1 year of operation from the Large ALWR and all its support facilities was calculated to be 172 person-rem. An additional 2.8 fatal cancers would result from 40 years of operation. The annual average worker dose was calculated to be 281 mrem. A fatal cancer risk of 4.5×10^{-3} could result to this worker from 40 years of operation. These results and health effects to workers are included in table E.2.3-1.

E.2.3.3.2 Small Advanced Light Water Reactor

Radioactive releases into the atmosphere and surface water for a "wet site" (ORR and SRS) and into the atmosphere for a "dry site" (INEL, NTS, and Pantex) from the Simplified Boiling Water Reactor and AP600 reactor are presented in tables E.2.3.3.2-1 and E.2.3.3.2-2, respectively.

The dose to the worker population for 1 year of operation from the Small ALWR and all its support facilities was calculated to be 102 person-rem. An additional 1.6 fatal cancers could result from 40 years of operation. The annual average worker dose was calculated to be 194 mrem. A fatal cancer risk of 3.1×10^{-3} could result to this worker from 40 years of operation. These doses and health effects are included in table E.2.3-1.

**TABLE E.2.3.3.1-1.—Annual Liquid and Atmospheric Radioactive Releases
from Large Advanced Light Water Reactor (Advanced Boiling Water Reactor) (curies)**

Isotope	Wet Site Releases		Dry Site Releases	Isotope	Wet Site Releases		Dry Site Releases
	Liquid	Air	Air		Liquid	Air	Air
H-3	7.6×10^3	8.6×10^{3a}	1.6×10^4	Mo-99	8.3×10^{-4}	0.015	0.016
C-14	0.0	9.2	9.2	Tc-99m	8.0×10^{-4}	3.0×10^{-4}	1.1×10^{-3}
Na-24	2.8×10^{-3}	4.1×10^{-3}	6.9×10^{-3}	Ru-103	1.8×10^{-4}	4.9×10^{-4}	6.7×10^{-4}
P-32	1.8×10^{-4}	9.2×10^{-4}	1.1×10^{-3}	Ru-106	1.7×10^{-4}	1.9×10^{-5}	1.9×10^{-4}
Ar-41	0.0	6.8	6.8	Rh-103m	9.0×10^{-6}	1.1×10^{-4}	1.2×10^{-4}
Cr-51	7.7×10^{-3}	0.035	0.043	Ag-110m	3.3×10^{-4}	6.5×10^{-7}	3.3×10^{-4}
Mn-54	2.6×10^{-3}	4.9×10^{-3}	7.5×10^{-3}	Sb-124	3.6×10^{-4}	1.7×10^{-4}	5.3×10^{-4}
Fe-55	5.8×10^{-3}	6.5×10^{-3}	0.012	Te-129m	1.7×10^{-5}	2.2×10^{-4}	2.4×10^{-4}
Mn-56	3.8×10^{-3}	3.5×10^{-3}	7.3×10^{-3}	Te-131m	3.4×10^{-5}	7.6×10^{-5}	1.1×10^{-4}
Fe-59	1.0×10^{-4}	6.5×10^{-4}	7.5×10^{-4}	Te-132	4.0×10^{-6}	1.9×10^{-5}	2.3×10^{-5}
Co-57	7.2×10^{-5}	0.0	7.2×10^{-5}	I-131	3.2×10^{-3}	0.26	0.26
Co-58	9.0×10^{-5}	2.4×10^{-3}	2.5×10^{-3}	I-132	2.6×10^{-3}	2.2	2.2
Co-60	9.1×10^{-3}	0.011	0.02	I-133	0.020	1.7	1.7
Ni-63	1.4×10^{-4}	6.5×10^{-6}	1.5×10^{-4}	I-134	1.7×10^{-3}	3.8	3.8
Cu-64	7.5×10^{-3}	0.010	0.018	I-135	7.5×10^{-3}	2.4	2.4
Zn-65	9.0×10^{-5}	8.1×10^{-3}	8.2×10^{-3}	Xe-131m	0	51	51
Kr-83m	0	8.4×10^{-4}	8.4×10^{-4}	Xe-133m	0	0.086	0.086
Kr-85m	0	21	21	Xe-133	0	2.4×10^3	2.4×10^3
Kr-85	0	570	570	Xe-135m	0	410	410
Kr-87	0	25	25	Xe-135	0	460	460
Kr-88	0	38	38	Xe-137	0	510	510
Kr-89	0	240	240	Xe-138	0	430	430
Kr-90	0	3.2×10^{-4}	3.2×10^{-4}	Cs-134	6.1×10^{-3}	1.7×10^{-4}	6.3×10^{-3}
Rb-89	4.4×10^{-5}	4.3×10^{-5}	8.7×10^{-5}	Cs-136	3.2×10^{-4}	8.1×10^{-5}	4.0×10^{-4}
Sr-89	1.1×10^{-4}	5.7×10^{-3}	5.8×10^{-3}	Cs-137	8.9×10^{-3}	4.6×10^{-4}	9.4×10^{-3}
Sr-90	3.5×10^{-5}	6.8×10^{-5}	1.0×10^{-4}	Cs-138	1.9×10^{-4}	1.7×10^{-4}	3.6×10^{-4}
Sr-91	9.0×10^{-4}	1.0×10^{-3}	1.9×10^{-3}	Ba-140	6.8×10^{-4}	0.013	0.014
Sr-92	8.0×10^{-4}	7.8×10^{-4}	1.6×10^{-3}	La-140	1.7×10^{-4}	1.8×10^{-3}	2.0×10^{-3}
Y-90	3.1×10^{-6}	4.6×10^{-5}	4.9×10^{-5}	Ce-141	1.2×10^{-4}	8.6×10^{-3}	8.8×10^{-3}
Y-91	1.1×10^{-4}	2.4×10^{-4}	3.5×10^{-4}	Ce-144	1.9×10^{-3}	1.9×10^{-5}	1.9×10^{-3}
Y-92	6.0×10^{-4}	6.2×10^{-4}	1.2×10^{-3}	Pr-143	1.3×10^{-6}	0	1.3×10^{-6}
Y-93	9.0×10^{-4}	1.1×10^{-3}	2.0×10^{-3}	Pr-144	0	1.9×10^{-5}	1.9×10^{-5}
Nb-95	1.0×10^{-3}	1.7×10^{-3}	2.7×10^{-3}	W-187	9.5×10^{-5}	1.9×10^{-4}	2.8×10^{-4}
Zr-95	8.4×10^{-4}	1.2×10^{-3}	2.0×10^{-3}	Np-239	3.1×10^{-3}	0.012	0.015

^a Includes tritium associated with target processing.

Source: DOE 1995f.

TABLE E.2.3.3.1-2.—Annual Liquid and Atmospheric Radioactive Releases
from Large Advanced Light Water Reactor (CE System 80+ Reactor) (curies)

Isotope	Wet Site Releases		Dry Site Releases	Isotope	Wet Site Releases		Dry Site Releases
	Liquid	Air	Air		Liquid	Air	Air
H-3	3.8×10^3	1.2×10^{4a}	1.6×10^4	Ag-110m	2.0×10^{-3}	0	2.0×10^{-3}
C-14	0	7.3	7.3	Sb-124	4.3×10^{-4}	0	4.3×10^{-4}
Na-24	2.2×10^{-3}	0	2.2×10^{-3}	Sb-125	0.0	6.1×10^{-7}	6.1×10^{-7}
P-32	1.8×10^{-4}	0	1.8×10^{-4}	Te-129m	1.0×10^{-4}	0	1.0×10^{-4}
Ar-41	0	34.0	34.0	Te-129	1.2×10^{-4}	0	1.2×10^{-4}
Cr-51	6.4×10^{-3}	3.3×10^{-5}	6.4×10^{-3}	Te-131m	1.6×10^{-4}	0	1.6×10^{-4}
Mn-54	4.8×10^{-3}	2.0×10^{-5}	4.8×10^{-3}	Te-131	3.6×10^{-5}	0	3.6×10^{-5}
Fe-55	8.0×10^{-3}	0.0	8.0×10^{-3}	Te-132	4.1×10^{-4}	0	4.1×10^{-3}
Fe-59	2.4×10^{-3}	8.8×10^{-6}	2.4×10^{-3}	I-131	0.02	0.019	0.039
Co-57	0	2.5×10^{-6}	2.5×10^{-6}	I-132	1.3×10^{-3}	0	1.3×10^{-3}
Co-58	0.011	3.1×10^{-4}	0.011	I-133	0.01	0.053	0.063
Co-60	0.014	9.5×10^{-5}	0.014	I-135	4.3×10^{-3}	0	4.3×10^{-3}
Ni-63	1.7×10^{-3}	0	1.7×10^{-3}	Xe-131m	0	830	830
Zn-65	3.2×10^{-4}	0	3.2×10^{-4}	Xe-133m	0	1	1
Kr-83m	0	8.4×10^{-4}	8.4×10^{-4}	Xe-133	0	660	660
Kr-85m	0	3	3.0	Xe-135m	0	4	4
Kr-85	0	800	800	Xe-135	0	24	24
Kr-87	0	4	4	Xe-138	0	3	3
Kr-88	0	8	8	Cs-139	0	3.1×10^{-5}	3.1×10^{-5}
Sr-89	1.7×10^{-4}	6.9×10^{-5}	2.4×10^{-4}	Cs-134	0.018	3.0×10^{-5}	0.018
Sr-90	2.0×10^{-5}	2.7×10^{-5}	4.7×10^{-5}	Cs-136	8.9×10^{-4}	1.0×10^{-5}	9.0×10^{-4}
Sr-91	2.8×10^{-5}	0	2.8×10^{-5}	Cs-137	0.026	5.2×10^{-5}	0.026
Y-91	9.0×10^{-5}	0	9.0×10^{-5}	Ba-140	7.0×10^{-3}	4.2×10^{-6}	7.0×10^{-3}
Y-91m	1.1×10^{-5}	0	1.1×10^{-5}	La-140	8.4×10^{-3}	0	8.4×10^{-3}
Y-93	1.2×10^{-4}	0	1.2×10^{-4}	Ce-141	3.1×10^{-4}	4.3×10^{-6}	3.2×10^{-4}
Nb-95	2.1×10^{-3}	3.0×10^{-5}	2.1×10^{-3}	Ce-143	3.4×10^{-4}	0	3.4×10^{-4}
Zr-95	1.3×10^{-3}	1.0×10^{-5}	1.3×10^{-5}	Ce-144	6.3×10^{-3}	0	6.3×10^{-3}
Mo-99	1.5×10^{-3}	0.6	1.5×10^{-3}	Pr-143	1.0×10^{-4}	0	1.0×10^{-4}
Tc-99m	1.3×10^{-3}	0	1.3×10^{-3}	Pr-144	2.3×10^{-3}	0	2.3×10^{-3}
Ru-103	4.5×10^{-3}	5.5×10^{-6}	4.5×10^{-3}	W-187	2.1×10^{-4}	0	2.1×10^{-4}
Ru-106	0.065	7.8×10^{-7}	0.065	Np-239	4.4×10^{-4}	0	4.4×10^{-4}
Rh-103m	4.1×10^{-3}	0	4.1×10^{-3}				

^a Includes tritium associated with target processing.

Source: DOE 1995f.

TABLE E.2.3.3.2-1.—Annual Liquid and Atmospheric Radioactive Releases from Small Advanced Light Water Reactor (Simplified Boiling Water Reactor) (curies)

Isotope	Wet Site Releases		Dry Site Releases	Isotope	Wet Site Releases		Dry Site Releases
	Liquid	Air ^a	Air		Liquid	Air ^a	Air
H-3	9.9×10^3	6.3×10^3	1.6×10^4	Y-90	3.0×10^{-6}	8.1×10^{-3}	8.1×10^{-3}
C-14	1.6×10^{-4}	5.9	5.9	Y-91	1.1×10^{-4}	0.043	0.043
Ar-41	0	5.4	5.4	Y-92	5.9×10^{-4}	0.068	0.068
Kr-83m	0	4.1×10^{-4}	4.1×10^{-4}	Y-93	8.9×10^{-4}	0.15	0.15
Kr-85m	0	5.7	5.7	Zr-95	8.4×10^{-4}	9.2×10^{-3}	0.01
Kr-85	0	300	300	Nb-95	1.0×10^{-3}	0.02	0.013
Kr-87	0	5.7	5.7	Mo-99	8.4×10^{-4}	0.57	0.57
Kr-88	0	8.6	8.6	Tc-99M	8.1×10^{-4}	0.051	0.052
Kr-89	0	54	54	Ru-103	1.8×10^{-4}	0.022	0.023
Kr-90	0	1.5×10^{-4}	1.5×10^{-4}	Rh-103M	8.9×10^{-6}	0.021	0.021
Xe-131m	0	23	23	Ag-110M	3.2×10^{-4}	8.4×10^{-7}	3.3×10^{-3}
Xe-133m	0	0.027	0.027	Sb-124	3.5×10^{-4}	7.6×10^{-5}	4.3×10^{-4}
Xe-133	0	970	970	Sb-125	0	0	0
Xe-135m	0	89	89	Te-129m	1.7×10^{-5}	0.041	0.041
Xe-135	0	140	140	Te-131M	3.5×10^{-5}	0.013	0.013
Xe-137	0	112	112	Te-131	0	0	0
Xe-138	0	89	89	I-131	3.2×10^{-3}	0.46	0.46
Xe-139	0	1.92×10^{-4}	1.92×10^{-4}	Te-132	4.1×10^{-6}	3.2×10^{-3}	3.2×10^{-3}
Na-24	2.7×10^{-3}	0.092	0.095	I-132	2.6×10^{-3}	1.7	1.7
P-32	1.8×10^{-4}	0.025	0.025	I-133	0.01	1.8	1.8
Cr-51	7.6×10^{-3}	0.89	0.90	I-134	1.7×10^{-3}	2.7	2.7
Mn-54	2.6×10^{-3}	0.014	0.017	Cs-134	6.2×10^{-3}	0.032	0.039
Mn-56	3.8×10^{-3}	0.057	0.061	I-135	7.6×10^{-3}	2.1	2.1
Fe-55	5.7×10^{-3}	0.18	0.18	Cs-136	3.2×10^{-4}	0.014	0.014
Co-57	7.3×10^{-5}	0	7.3×10^{-5}	Cs-137	8.9×10^{-3}	0.084	0.93
Co-58	8.9×10^{-5}	0.032	0.033	Cs-138	1.9×10^{-4}	0.011	0.012
Co-60	9.2×10^{-3}	0.076	0.085	Cs-139	0	1.4×10^{-5}	1.4×10^{-5}
Fe-59	1.00×10^{-4}	5.1×10^{-3}	5.2×10^{-3}	Ba-140	6.8×10^{-4}	0.32	0.33
Ni-63	1.4×10^{-4}	1.8×10^{-4}	3.2×10^{-4}	La-140	1.7×10^{-4}	0.3	0.3
Cu-64	7.6×10^{-3}	0.23	0.24	Ce-141	1.2×10^{-4}	0.035	0.035
Zn-65	8.9×10^{-5}	0.038	0.038	Ce-144	1.9×10^{-3}	3.5×10^{-3}	5.4×10^{-3}
Rb-89	4.3×10^{-5}	2.6×10^{-3}	2.6×10^{-3}	Pr-143	1.3×10^{-6}	0	1.3×10^{-6}
Sr-89	1.1×10^{-4}	0.11	0.11	Pr-144	0	3.5×10^{-3}	3.5×10^{-3}
Sr-90	3.5×10^{-5}	8.1×10^{-3}	8.1×10^{-3}	W-187	9.5×10^{-5}	4.6×10^{-3}	4.7×10^{-3}
Sr-91	8.9×10^{-4}	0.14	0.14	Np-239	3.0×10^{-3}	1.9	1.9
Sr-92	8.1×10^{-4}	0.081	0.082				

^a Includes tritium associated with target processing.

Source: DOE 1995f.

TABLE E.2.3.3.2-2.—Annual Liquid and Atmospheric Radioactive Releases
from Small Advanced Light Water Reactor (AP600 Reactor) (curies)

Isotope	Wet Site Releases		Dry Site Releases	Isotope	Wet Site Releases		Dry Site Releases
	Liquid	Air ^a	Air		Liquid	Air ^a	Air
H-3	1.5x10 ⁴	1.6x10 ³	1.6x10 ⁴	Zr-95	1.2x10 ⁻³	1.0x10 ⁻³	2.2x10 ⁻³
C-14	0	7.3	7.3	Nb-95	1.9x10 ⁻³	2.5x10 ⁻³	4.4x10 ⁻³
Ar-41	0	34	34.0	Mo-99	8.1x10 ⁻⁴	0	8.1x10 ⁻⁴
Kr-85m	0	31	31.0	Tc-99M	4.8x10 ⁻⁴	0	4.8x10 ⁻⁴
Kr-85	0	180	180	Ru-103	1.4x10 ⁻³	8.0x10 ⁻⁵	1.5x10 ⁻³
Kr-87	0	10	10	Rh-103M	1.1x10 ⁻³	0	1.1x10 ⁻³
Kr-88	0	35	35	Ru106	0.022	7.8x10 ⁻⁵	0.022
Xe-131m	0	1.0x10 ³	1.0x10 ³	Ag-110M	1.4x10 ⁻³	0	1.4x10 ⁻³
Xe-133m	0	53.0	53	Sb-124	4.3x10 ⁻⁴	0	4.3x10 ⁻⁴
Xe-133	0	2.9x10 ³	2.9x10 ³	Sb-125	0	6.1x10 ⁻⁵	6.1x10 ⁻⁵
Xe-135m	0	4	4.0	Te-129M	3.0x10 ⁻⁵	0	3.0x10 ⁻⁵
Xe-135	0	220	220	Te-129	3.0x10 ⁻⁵	0	3.0x10 ⁻⁵
Xe-138	0	3	3.0	Te-131M	1.4x10 ⁻⁴	0	1.4x10 ⁻⁴
Xe-139	0	1.92x10 ⁻⁴	1.92x10 ⁻⁴	Te-131	3.0x10 ⁻⁵	0	3.0x10 ⁻⁵
Na-24	3.2x10 ⁻³	0	3.2x10 ⁻³	I-131	0.033	0.066	0.099
P-32	1.8x10 ⁻⁴	0	1.8x10 ⁻⁴	Te-132	2.0x10 ⁻⁴	0	2.0x10 ⁻⁴
Cr-51	5.2x10 ⁻³	6.1x10 ⁻⁴	5.8x10 ⁻³	I-132	2.3x10 ⁻³	0	2.3x10 ⁻³
Mn-54	4.4x10 ⁻³	4.4x10 ⁻⁴	4.4x10 ⁻³	I-133	0.02	0.24	0.26
Fe-55	7.4x10 ⁻³	0	7.4x10 ⁻³	I-134	9.0x10 ⁻⁵	0	9.0x10 ⁻⁵
Co-57	0	8.2x10 ⁻⁶	8.2x10 ⁻⁶	Cs-134	0.027	0.023	0.029
Co-58	8.6x10 ⁻³	0.023	0.032	I-135	0.015	0	0.015
Co-60	0.014	8.7x10 ⁻³	0.023	Cs-136	1.5x10 ⁻³	8.5x10 ⁻⁵	1.6x10 ⁻³
Fe-59	2.2x10 ⁻³	7.9x10 ⁻⁵	2.3x10 ⁻³	Cs-137	0.037	3.6x10 ⁻³	0.041
Ni-63	1.7x10 ⁻³	0	1.7x10 ⁻³	Ba-140	2.7x10 ⁻³	4.2x10 ⁻⁴	3.1x10 ⁻³
Zn-65	8.0x10 ⁻⁵	0	8.0x10 ⁻⁵	La-140	2.8x10 ⁻³	0	2.8x10 ⁻³
Sr-89	1.1x10 ⁻⁴	3.0x10 ⁻³	3.1x10 ⁻³	Ce-141	2.5x10 ⁻⁴	4.2x10 ⁻⁵	2.9x10 ⁻⁴
Sr-90	2.0x10 ⁻⁵	1.2x10 ⁻³	1.2x10 ⁻³	Ce-143	2.7x10 ⁻⁴	0	2.7x10 ⁻⁴
Sr-91	5.0x10 ⁻⁵	0	5.0x10 ⁻⁵	Ce-144	4.5x10 ⁻³	0	4.5x10 ⁻³
Y-91m	3.0x10 ⁻⁵	0	3.0x10 ⁻⁵	Pr-144	5.8x10 ⁻⁴	0	5.8x10 ⁻⁴
Y-91	9.0x10 ⁻⁵	0	9.0x10 ⁻⁵	W-187	2.2x10 ⁻⁴	0	2.2x10 ⁻⁴
Y-93	2.2x10 ⁻⁴	0	2.2x10 ⁻⁴	Np-239	2.5x10 ⁻⁴	0	2.5x10 ⁻⁴

^a Includes tritium associated with target processing.
Source: DOE 1995f.

E.2.3.4 Accelerator Production of Tritium

Sandia National Laboratories, New Mexico, has evaluated the radiological emissions and Los Alamos National Laboratory has assessed the possible effects of radio frequency power generated, using an accelerator, from the production of tritium.

Two separate tritium target designs have been proposed. The first uses targets using the same concept as in the HWR reactor; irradiation of a spallation-induced lithium conversion target. The second uses a different concept; irradiation of helium-3. The accelerator is the same design for either target system. The differences between the two target designs arise in the tritium extraction process discussed below. In addition, a "phased" accelerator with a helium target is being evaluated. Table E.2.3.4-1 presents the atmospheric releases. There are no liquid radioactive releases.

TABLE E.2.3.4-1.—Annual Atmospheric Releases from Accelerator Production of Tritium During Normal Operation (curies)

Isotope	Full APT	Phased APT
C-11	11	3.8
N-13	0.49	0.17
O-14	9.8×10^{-16}	3.5×10^{-16}
O-15	6.5×10^{-8}	2.3×10^{-8}
Ar-41	7.1	2.5

Source: SNL 1995a.

The radio frequency power generated by the APT accelerator does not produce hazardous exposures of radio frequency non-ionizing radiation to workers, nor does it interfere with radio/television or other sensitive signal equipment, on or offsite. The radio frequency power generators in the APT accelerator system are completely contained in connected, sealed, metallic enclosures. The enclosure provides a continuous metal-sealed envelope which contains the microwave energy. Also, the accelerating cavities and attachments constitute a tightly sealed vacuum system which ensures a much greater shield than is needed for preventing leakage of radio frequency energy. Therefore, the potential for a significant level of microwave energy being radiated to the surroundings of the APT accelerator is negligible. The experience with the Los Alamos Meson Physics Facility at Los Alamos and other DOE accelerators

confirms that there is minimal leakage of radio frequency power which poses no hazard to workers or to television/radio or other sensitive signal-processing equipment.

The dose to the worker population for 1 year of operation from the APT and all its support facilities with the spallation-induced lithium conversion target was calculated to be 42 person-rem. An additional 0.68 fatal cancers could result from 40 years of operation. The annual average worker dose was calculated to be 64 mrem. A fatal cancer risk of 1.0×10^{-3} could result to this worker from 40 years of operation. The dose to the worker population for 1 year of operation from the APT and all its support facilities with the helium-3 conversion target was calculated to be 40 person-rem. An additional 0.64 fatal cancers could result from 40 years of operation. The annual average worker dose was calculated to be 61 mrem. A fatal cancer risk of 9.7×10^{-4} could result to this workers from 40 years of operation. A Phased APT is comparable to the APT with the helium-3 target. The dose and health effects associated with all APT options are given in table E.2.3-1.

E.2.3.5 Tritium Target Extraction Facility

This facility extracts the tritium from the targets after completion of the irradiation in either the reactor or accelerator. Table E.2.3.5-1 presents the atmospheric radiological releases. There are no liquid radioactive releases. The impacts to workers and the public associated with extraction are included in the various reactor/accelerator calculations.

TABLE E.2.3.5-1.—Annual Atmospheric Releases of Tritium from Various Tritium Target Extraction Facilities for Tritium Supply Technologies (curies)

Tritium Extraction Facility Contribution	Atmospheric Release of Tritium
Heavy Water Reactor	5.0×10^3
Modular High Temperature Gas-Cooled Reactor	5.0×10^3
Advanced Light Water Reactor	5.0×10^3
Accelerator - Helium-3 Target	250
Accelerator - Spallation-Induced Lithium Conversion Target	5.0×10^3

Source: DOE 1995d; DOE 1995e; DOE 1995f; SNL 1995a.

E.2.3.6 Tritium Recycling Facility

The *Data Report on Tritium Recycling Plant* (February 1995) describes the facility for the recycling of the tritium. Simply, this facility receives tritium from either the tritium supply or dismantled weapons to purify and prepare the tritium for placement into nuclear weapons. The predicted release of tritium into the atmosphere is estimated to range from 5,000 to 10,000 Ci per year. For this PEIS, the higher value was assumed. There are no liquid radioactive releases. The impacts to workers are included in the various reactor/accelerator calculations.

An upgraded tritium recycling facility is being evaluated for operation at SRS. The unconsolidated upgrade involves maintaining many functions in Building 232-H. As a potential mitigation measure a consolidated upgrade is considered that includes the relocation of all tritium processing/handling associated with tritium recycling facilities to other buildings. The predicted tritium releases into the atmosphere from the unconsolidated and consolidated upgrade options are 30,000 Ci per year and 18,000 Ci per year, respectively.

E.2.4 Radiological Impacts at Idaho National Engineering Laboratory

This section presents the radiological impacts of the tritium supply technologies and recycling facilities at INEL. Section E.2.4.1 presents the radiological releases and resulting impacts from facilities associated with No Action. Section E.2.4.2 presents the radiological releases and resulting impacts from the facilities associated with tritium supply technologies and recycling facilities.

For purposes of radiological impact modeling, INEL was divided into five areas which will release radioactivity in the year 2010. All release points in each area were aggregated into a single release point. Table E.2.4-1 presents the characteristics of each of the release points including location, release height, minimum distance, and annual average dispersion to the site boundary in each of the 16 directions. In order to calculate the maximum site boundary dose, the dose from each release point to the maximum receptor associated with each of the other release points has been calculated. For example, the dose resulting from releases from the Test Reactor Area, Argonne National Laboratory-West, Waste Experimental Reduction Facility/Power Burst Facility Area, and the proposed TSS has been determined for the maximum receptor from the Central Facilities Area. Figure E.2.4-1 illustrates the location of each maximum receptor in relation to each release point. The maximum site boundary dose is then determined by the maximum dose of each of the maximum receptors. Table E.2.4-2 presents the direction, distance, and atmospheric dispersion from each release point to each of the maximum receptors. Annual radiological releases were assumed to remain constant during the 40-year operational period.

The population and food stuffs distributions centered on each release area are provided in the *Health Risk Data* report. The joint frequency distribution used for the dose assessment was based on the meteorological measurements for the year 1986 from the GRID III tower at the 10-meter height and is contained in a technical report (*Health Risk Data*).

Doses given in this section are associated with 1 year of operation because regulatory standards are given as annual limits. The health effects presented are for the 40-year operational period.

E.2.4.1 No Action

Atmospheric Releases. For No Action, four of the areas have radioactive releases into the atmosphere from normal operation. Table E.2.4.1-1 presents the estimated annual atmospheric radioactive releases.

Liquid Releases. There are no radioactive liquid releases into the offsite environment associated with No Action.

Tables E.2.4.1-2 and E.2.4.1-3 include the radiological impacts to the maximally exposed individual and offsite population within 50 miles, respectively. The maximally exposed individual would receive an annual dose of 6.0×10^{-3} mrem. An estimated fatal cancer risk of 1.2×10^{-7} would result from 40 years of operation. The population within 50 miles would receive a dose of 0.037 person-rem in year 2030 (mid-life of operation). An estimated 7.4×10^{-4} fatal cancers could result from 40 years of operation.

Worker Doses. Based on measured values during the time period of 1989 to 1992 (*Twenty-Second Annual Report Radiation Exposures for DOE and DOE Contractor Employees - 1989* (DOE/EH-0286P)) and subsequent yearly data reports, the annual average dose to a badged worker at INEL was calculated to be 30 mrem. It is projected that in the year 2010 and beyond, there would be 7,337 badged workers involved in No Action activities at INEL (INEL 1993a:5). The annual average dose to these workers is assumed to remain at 30 mrem; the annual total dose among all these workers would then equal 220 person-rem. From 40 years of operation, an estimated fatal cancer risk of 4.8×10^{-4} would result to the average worker and 3.5 fatal cancers could result among all workers.

E.2.4.2 Tritium Supply Technologies and Recycling

For the tritium supply technologies and recycling facilities, the impacts from the No Action facilities need to be added to the impacts from the tritium supply technologies and recycling facilities to determine the impacts from total site operation. For example, to determine the radiological impact for the addition of an HWR at INEL, the doses from No Action facilities would be summed with the HWR doses (which includes tritium target extraction) and

the tritium recycling doses. Estimated annual atmospheric radioactive releases for the tritium supply technologies and recycling facilities are given in section E.2.3. Tables E.2.4.1-2 and E.2.4.1-3 present the radiological impacts by tritium supply technology and recycling facility. There are no radioactive liquid releases to the offsite environment associated with this alternative.

The annual doses from total site operation associated with the difference tritium supplies ranged from 0.11 to 0.36 mrem to the maximally exposed individual and from 23 to 73 person-rem to the 50-mile population in the year 2030. The health effects from 40 years of operation are included in both tables.

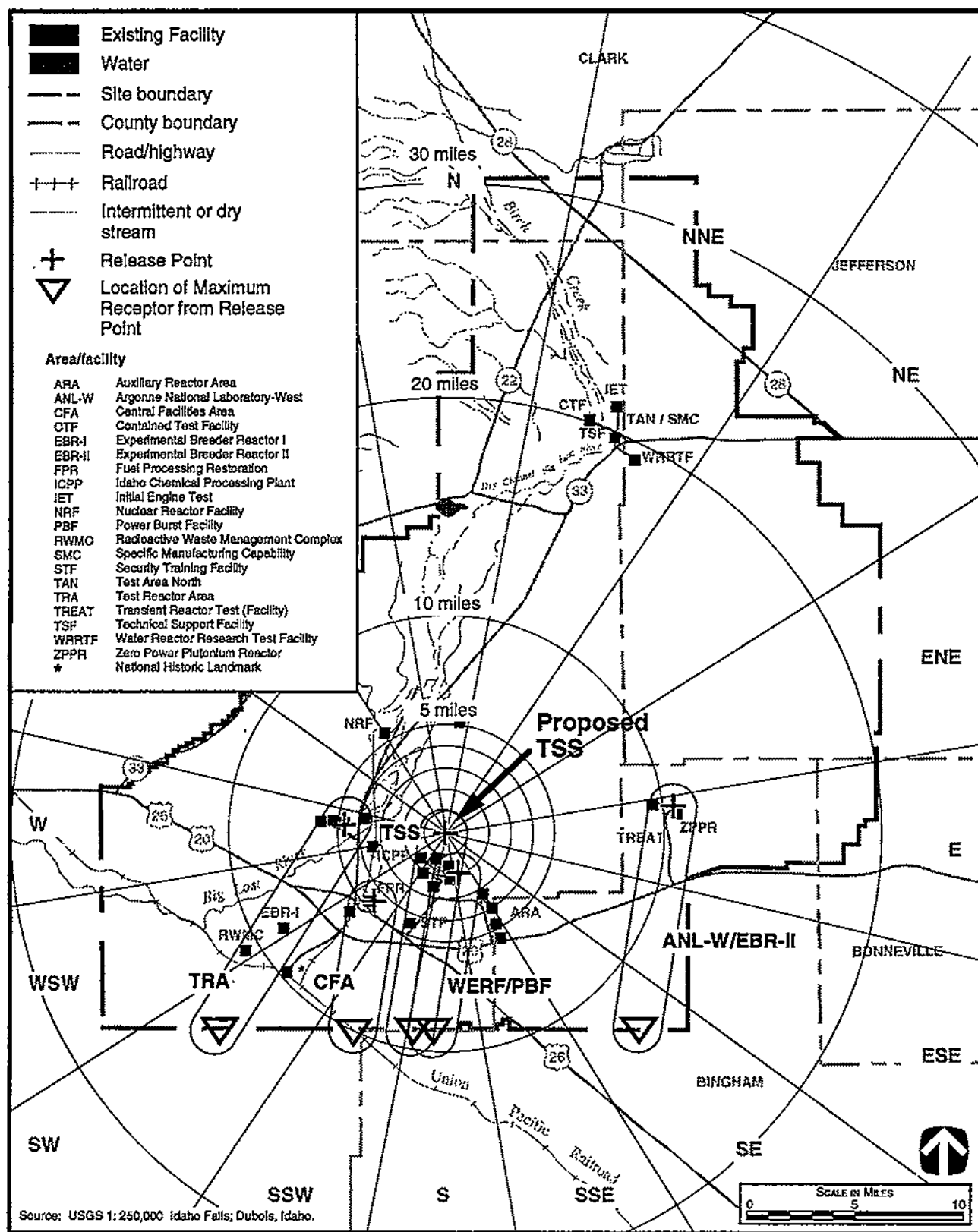


FIGURE E.2.4-1.—Location of Maximum Receptors at Idaho National Engineering Laboratory.

TABLE E.2.4-1.—Release Point Characteristics, Direction, Distance, and Chi/Q at Idaho National Engineering Laboratory Boundary

Release Point ^a	Argonne National Laboratory-West		Central Facilities Area		Test Reactor Area		Facility/Power Burst Reduction		Tritium Supply and Recycling Site	
	Latitude	Longitude	Area	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)	Distance (m)
Release Height:	43°35'41.63"	-112°39'18.71"	43°32'4.56"	-112°56'9.95"	43°35'8.17"	-112°57'46.79"	43°33'3.60"	-112°51'30.95"	43°34'42.60"	-112°52'5.53"
	18.1 meters		Ground Level		76.2 meters		15.0 meters		Ground Level	

Direction	Annual Average		50 Percentile		95 Percentile	
	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)
N.	32,636	1.2x10 ⁻⁸	24,783	1.1x10 ⁻⁸	19,099	3.3x10 ⁻⁹
NNNE.	24,647	2.0x10 ⁻⁸	40,102	1.1x10 ⁻⁸	21,737	6.8x10 ⁻⁹
NE.	19,641	2.3x10 ⁻⁸	45,055	2.3x10 ⁻⁸	42,898	7.3x10 ⁻⁹
ENE.	16,056	2.2x10 ⁻⁸	39,301	2.0x10 ⁻⁸	41,932	4.6x10 ⁻⁹
E.	14,466	1.6x10 ⁻⁸	23,843	1.5x10 ⁻⁸	26,375	2.9x10 ⁻⁹
ESE.	9,003	2.8x10 ⁻⁸	18,763	1.0x10 ⁻⁸	26,410	1.4x10 ⁻⁹
SE.	5,861	5.0x10 ⁻⁸	11,883	9.4x10 ⁻⁹	19,094	1.0x10 ⁻⁹
SSE.	5,518	9.2x10 ⁻⁸	10,161	1.7x10 ⁻⁸	15,967	1.6x10 ⁻⁹
S.	5,572	1.2x10 ⁻⁷	9,887	5.3x10 ⁻⁸	15,538	5.2x10 ⁻⁹
SSW.	17,066	3.7x10 ⁻⁸	10,022	7.5x10 ⁻⁸	15,754	1.0x10 ⁻⁸
SW.	19,889	3.1x10 ⁻⁸	11,654	6.4x10 ⁻⁸	18,300	1.2x10 ⁻⁸
WSW.	28,928	1.7x10 ⁻⁸	16,968	1.5x10 ⁻⁸	18,987	3.3x10 ⁻⁹
W.	35,299	9.6x10 ⁻⁹	20,727	1.6x10 ⁻⁸	17,013	5.2x10 ⁻⁹
WNW.	32,525	8.3x10 ⁻⁹	19,193	5.2x10 ⁻⁹	12,186	2.2x10 ⁻⁹
NW.	27,828	1.0x10 ⁻⁸	17,202	9.7x10 ⁻⁹	11,503	2.9x10 ⁻⁹
NNW.	31,168	1.3x10 ⁻⁸	17,397	1.0x10 ⁻⁸	12,205	3.4x10 ⁻⁹

Direction	Annual Average		50 Percentile		95 Percentile	
	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)
N.	22,328	1.2x10 ⁻⁸	25,459	8.5x10 ⁻⁹	22,328	1.2x10 ⁻⁸
NNNE.	44,888	9.8x10 ⁻⁹	41,136	9.4x10 ⁻⁹	44,888	9.8x10 ⁻⁹
NE.	37,707	2.9x10 ⁻⁸	39,207	2.4x10 ⁻⁸	37,707	2.9x10 ⁻⁸
ENE.	34,097	2.5x10 ⁻⁸	32,888	2.1x10 ⁻⁸	34,097	2.5x10 ⁻⁸
E.	19,375	2.0x10 ⁻⁸	17,582	1.9x10 ⁻⁸	19,375	2.0x10 ⁻⁸
ESE.	18,696	1.0x10 ⁻⁸	17,858	8.8x10 ⁻⁹	18,696	1.0x10 ⁻⁸
SE.	18,259	5.2x10 ⁻⁹	14,536	5.9x10 ⁻⁹	18,259	5.2x10 ⁻⁹
SSE.	14,689	1.0x10 ⁻⁸	11,541	1.1x10 ⁻⁸	14,689	1.0x10 ⁻⁸
S.	14,635	3.1x10 ⁻⁸	11,539	3.5x10 ⁻⁸	14,635	3.1x10 ⁻⁸
SSW.	15,029	4.3x10 ⁻⁸	11,938	4.8x10 ⁻⁸	15,029	4.3x10 ⁻⁸
SW.	17,460	3.7x10 ⁻⁸	13,874	4.2x10 ⁻⁸	17,460	3.7x10 ⁻⁸
WSW.	25,441	8.9x10 ⁻⁹	20,229	1.0x10 ⁻⁸	25,441	8.9x10 ⁻⁹
W.	24,305	1.3x10 ⁻⁸	26,938	9.4x10 ⁻⁹	24,305	1.3x10 ⁻⁸
WNW.	17,918	5.7x10 ⁻⁹	21,125	3.9x10 ⁻⁹	17,918	5.7x10 ⁻⁹
NW.	17,909	9.2x10 ⁻⁹	20,319	6.4x10 ⁻⁹	17,909	9.2x10 ⁻⁹
NNW.	20,732	8.2x10 ⁻⁹	23,854	5.7x10 ⁻⁹	20,732	8.2x10 ⁻⁹

^a See figure 4.2.2.1-2 for location of release points.
Source: HNUS 1995a.

TABLE E.2.4-2.—Direction, Distance, and Meteorological Dispersion to Various Maximum Individual Receptors at Idaho National Engineering Laboratory Site Boundary

	Direction	Distance (m)	Maximum Receptor For:	Atmospheric Dispersion ChI/Q (s/m ³)
Release Point: Central Facilities Area				
	SSW.	10,021	Central Facilities Area	7.5x10 ⁻⁸
	SW.	15,469	Test Reactor Area	4.3x10 ⁻⁸
	SSE.	10,776	Waste Experimental Reduction Facility/Power Burst Facility	1.5x10 ⁻⁸
	ESE.	22,147	Argonne National Laboratory-West	8.0x10 ⁻⁹
	SSE.	10,329	Tritium Supply Site	1.6x10 ⁻⁸
Release Point: Test Reactor Area				
	S.	15,549	Central Facilities Area	5.2x10 ⁻⁹
	SW.	18,300	Test Reactor Area	1.2x10 ⁻⁸
	SSE.	16,849	Waste Experimental Reduction Facility/Power Burst Facility	1.5x10 ⁻⁹
	SE.	26,967	Argonne National Laboratory-West	7.4x10 ⁻¹⁰
	SSE.	16,392	Tritium Supply Site	1.5x10 ⁻⁹
Release Point: WERF/PBF				
	SW.	14,170	Central Facilities Area	4.1x10 ⁻⁸
	WSW.	21,628	Test Reactor Area	9.2x10 ⁻⁹
	SSW.	11,938	Waste Experimental Reduction Facility/Power Burst Facility	4.8x10 ⁻⁸
	SE.	17,963	Argonne National Laboratory-West	4.4x10 ⁻⁹
	SSW.	12,217	Tritium Supply Site	4.7x10 ⁻⁸
Release Point: ANL-West/EBR-II				
	WSW.	29,538	Central Facilities Area	1.7x10 ⁻⁸
	WSW.	38,409	Test Reactor Area	1.2x10 ⁻⁸
	SW.	24,904	Waste Experimental Reduction Facility/Power Burst Facility	2.3x10 ⁻⁸
	SSW.	17,066	Argonne National Laboratory-West	3.7x10 ⁻⁸
	SW.	25,872	Tritium Supply Site	2.2x10 ⁻⁸
Release Point: Tritium Supply Site				
	SSW.	16,430	Central Facilities Area	3.8x10 ⁻⁸
	SW.	22,813	Test Reactor Area	2.6x10 ⁻⁸
	S.	14,873	Waste Experimental Reduction Facility/Power Burst Facility	3.0x10 ⁻⁸
	SE.	20,645	Argonne National Laboratory-West	4.4x10 ⁻⁹
	SSW.	15,029	Tritium Supply Site	4.3x10 ⁻⁸

Note: WERF/PBF - Waste Experimental Reduction Facility/Power Burst Facility; ANL-W/EBR-II Argonne National Laboratory-West/Experimental Breeder Reactor-II.

Source: HNUS 1995a.

TABLE E.2.4.1-1.—Annual Atmospheric Radioactive Releases from Normal Operation
of No Action at Idaho National Engineering Laboratory (curies)

Isotope	Argonne National Laboratory-West	Central Facilities Area	Test Reactor Area ^a	Waste Experimental Reduction Facility/ Power Burst Facility
H-3	2.3	0	0	0
Na-24	0	0	3.2×10^{-3}	0
Cr-51	0	0	5.1×10^{-3}	0
Mn-54	0	0	2.4×10^{-6}	0
Co-58	0	0	2.4×10^{-6}	0
Co-60	0	1.3×10^{-6}	4.6×10^{-5}	2.1×10^{-8}
Rb-88	0	0	0.5	0
Rb-89	0	0	0.73	0
Sr-90	3.0×10^{-5}	3.7×10^{-6}	4.1×10^{-4}	1.6×10^{-6}
Y-91m	0	0	7.1×10^{-4}	0
Tc-99m	0	0	2.6×10^{-3}	0
Mo-99	0	0	5.3×10^{-6}	0
I-131	2.2×10^{-4}	0	8.3×10^{-4}	4.1×10^{-6}
I-132	9.1×10^{-4}	0	1.2×10^{-3}	0
I-133	3.7×10^{-4}	0	6.3×10^{-4}	0
I-134	0	0	1.1×10^{-3}	0
Cs-134	0	0	9.6×10^{-7}	0
Cs-137	0	6.3×10^{-8}	3.2×10^{-6}	1.8×10^{-7}
Cs-138	0	0	0.71	0
Ba-139	0	0	0.051	0
Ba-140	2.3×10^{-3}	0	9.4×10^{-6}	0
La-140	0	0	1.4×10^{-5}	0
Hg-203	0	0	3.6×10^{-4}	0
Os-191	0	0	6.6×10^{-4}	0
Pu-239	8.0×10^{-6}	9.6×10^{-7}	7.4×10^{-7}	1.3×10^{-7}
Ar-41	57	0	3.2×10^3	0
Kr-85	0.18	0	0	0
Kr-85m	21	0	22	0
Kr-87	24	0	68	0
Kr-88	24	0	66	0
Xe-131m	0.1	0	0	0
Xe-133	450	0	25	0
Xe-133m	1.8×10^{-3}	0	0	0
Xe-135	120	0	79	0
Xe-135m	5.5	0	40	0
Xe-138	15	0	200	0

^a Ignores contribution of Re-188 with 1.3×10^{-4} curies.

Source: INEL 1993a:5.

TABLE E.2.4.1-2.—Doses and Resulting Health Effect to the Maximally Exposed Individual Resulting from Normal Operation at Idaho National Engineering Laboratory

Alternative	Dose by Pathway (mrem per year)					Committed Effective Dose Equivalent (mrem per year)	Percent of Background ^a	Estimated 40-Year Fatal Cancer Risk
	Inhalation	Ingestion	Plume Immersion	Ground Shine				
No Action	3.1x10 ⁻⁵	1.7x10 ⁻⁵	5.9x10 ⁻³	9.5x10 ⁻⁶		6.0x10 ⁻³	1.7x10 ⁻³	1.2x10 ⁻⁷
No Action Contribution to Tritium Supply Site Maximum Receptor	2.1x10 ⁻⁵	1.7x10 ⁻⁵	1.2x10 ⁻³	2.6x10 ⁻⁶		1.2x10 ⁻³	3.5x10 ⁻⁴	2.5x10 ⁻⁸
Heavy Water Reactor	0.039	0.14	4.2x10 ⁻⁴	1.8x10 ⁻⁴		0.18	0.052	3.7x10 ⁻⁶
Modular High Temperature Gas-Cooled Reactor	5.2x10 ⁻³	0.071	1.0x10 ⁻⁴	5.1x10 ⁻⁵		0.077	0.022	1.5x10 ⁻⁶
Advanced Boiling Water Reactor	0.016	0.24	3.2x10 ⁻³	7.0x10 ⁻⁴		0.25	0.072	5.1x10 ⁻⁶
CE System 80+	0.016	0.23	4.9x10 ⁻⁴	3.2x10 ⁻⁴		0.24	0.069	4.9x10 ⁻⁶
Simplified Boiling Water Reactor	0.016	0.24	8.9x10 ⁻⁴	1.7x10 ⁻³		0.25	0.072	5.1x10 ⁻⁶
AP600	0.016	0.23	1.5x10 ⁻³	4.9x10 ⁻⁴		0.24	0.069	4.9x10 ⁻⁶
Full Accelerator Production of Tritium with helium-3	1.8x10 ⁻⁴	2.5x10 ⁻³	1.5x10 ⁻⁵	6.6x10 ⁻¹⁰		2.7x10 ⁻³	7.7x10 ⁻⁴	5.4x10 ⁻⁸
Full Accelerator Production of Tritium with spallation-induced lithium conversion	3.6x10 ⁻³	0.049	1.5x10 ⁻⁵	6.6x10 ⁻¹⁰		0.053	0.015	1.1x10 ⁻⁶
Phased Accelerator Production of Tritium	1.8x10 ⁻⁴	2.5x10 ⁻³	7.6x10 ⁻⁶	3.4x10 ⁻¹⁰		2.7x10 ⁻³	7.7x10 ⁻⁴	5.4x10 ⁻⁸
Tritium Recycling	7.3x10 ⁻³	0.099	6.9x10 ⁻¹²	0		0.11	0.031	2.2x10 ⁻⁶

^a Individual annual natural background radiation is equal to 353 mrem.
Source: HNUS 1995a.

TABLE E.2.4.1-3.—Doses and Resulting Health Effect to the Population Within 50 Miles Resulting from Normal Operation at Idaho National Engineering Laboratory

Alternative	Dose by Pathway in 2030 (person-rem)				Committed Effective Dose Equivalent in 2030 (person-rem)	Percent of Background ^a	Estimated 40-Year Fatal Cancers
	Inhalation	Ingestion	Plume Immersion	Ground Shine			
No Action	4.1x10 ⁻⁴	8.0x10 ⁻³	0.029	4.6x10 ⁻⁵	0.037	7.0x10 ⁻⁵	7.4x10 ⁻⁴
Heavy Water Reactor	0.33	31	1.8x10 ⁻³	1.5x10 ⁻³	31	0.058	0.62
Modular High Temperature Gas-Cooled Reactor	0.044	15	4.1x10 ⁻⁴	3.3x10 ⁻⁴	15	0.027	0.29
Advanced Boiling Water Reactor	0.13	51	0.011	4.8x10 ⁻³	51	0.096	1
CE System 80+	0.13	49	2.5x10 ⁻³	2.7x10 ⁻³	49	0.092	0.98
Simplified Boiling Water Reactor	0.13	49	3.6x10 ⁻³	0.014	49	0.092	0.98
AP600	0.13	49	8.9x10 ⁻³	4.1x10 ⁻³	49	0.092	0.98
Full Accelerator Production of Tritium with helium-3	1.5x10 ⁻³	0.53	4.7x10 ⁻⁵	3.7x10 ⁻¹¹	0.53	1.0x10 ⁻³	0.011
Full Accelerator Production of Tritium with spallation-induced lithium conversion	0.031	10	4.7x10 ⁻⁵	3.7x10 ⁻¹¹	10	0.019	0.2
Phased Accelerator Production of Tritium	1.5x10 ⁻³	0.53	2.4x10 ⁻⁵	1.9x10 ⁻¹¹	0.53	1.0x10 ⁻³	0.011
Tritium Recycling	0.061	21	5.8x10 ⁻¹¹	0	22	0.041	0.44

^a Dose to the population within 50 miles from natural background radiation in year 2030 is equal to 53,270 person-rem.
Source: HNUS 1995a.

E.2.5 Radiological Impacts at Nevada Test Site

This section presents the radiological impacts of the tritium supply technologies and recycling facilities at NTS. Section E.2.5.1 presents the radiological releases and resulting impacts from facilities associated with No Action. Section E.2.5.2 presents the radiological releases and resulting impacts from the facilities associated with tritium supply technologies and recycling facilities.

For purposes of radiological impact modeling, NTS was divided into seven areas which will release radioactivity in the year 2010. All release points in each area were aggregated into a single release point. Table E.2.5-1 presents the characteristics of each of the release points including location, release height, minimum distance, and annual average dispersion to the site boundary in each of the 16 directions. In order to calculate the maximum site boundary dose, the dose from each release point to the maximum receptor associated with each of the other release points has been calculated. For example, the dose resulting from releases for Areas 5, 6, 12, 19, 23, and the proposed TSS has been determined from the maximum receptor for Area 3. Figure E.2.5-1 illustrates the location of each maximum receptor in relation to each release point. The maximum site boundary dose is then determined by the maximum dose of each of the maximum receptors. Table E.2.5-2 presents the direction, distance, and atmospheric dispersion from each release point to each of the maximum receptors. Annual radiological releases were assumed to remain constant during the 40-year operational period.

The population and food stuffs distributions centered on each release area are provided in the *Health Risk Data* report. The joint frequency distribution used for the dose assessment was based on the meteorological measurements for the year 1990 from Desert Rock at the 10 meter height and is contained in a technical report (*Health Risk Data*).

Doses given in this section are associated with 1 year of operation because regulatory standards are given as annual limits. The health effects presented are for the 40-year operational period.

E.2.5.1 No Action

Atmospheric Releases. For No Action, six of the areas have radioactive releases into the atmosphere from normal operation. Table E.2.5.1-1 presents the estimated annual atmospheric radioactive releases.

Liquid Releases. There are no radioactive liquid releases into the offsite environment associated with No Action.

Tables E.2.5.1-2 and E.2.5.1-3 respectively, include the radiological impacts to the maximally exposed member of the public and offsite population within 50 miles. The maximally exposed individual would receive an annual dose of 0.040 mrem. An estimated fatal cancer risk of 8.1×10^{-7} would result from 40 years of operation. The population within 50 miles would receive a dose of 8.2×10^{-3} person-rem in year 2030 (mid-life of operation). An estimated 1.6×10^{-4} fatal cancers could result from 40 years of operation.

Workers Doses. Based on measured values during the time period of 1989 to 1992 (*Twenty-Second Annual Report Radiation Exposures for DOE and DOE Contract Employees - 1989* (DOE/EH-0286P)) and subsequent yearly dose reports, the annual average dose to a badged worker at NTS was calculated to be 5 mrem. It is projected that in the year 2010 and beyond, there would be 619 badged workers involved in No Action activities at NTS (NTS 1993a:4). The annual average dose to these workers was assumed to remain at 5 mrem; the annual total dose among all these workers would then equal 3 person-rem. From 40 years of operation, an estimated fatal cancer risk of 7.8×10^{-5} would result to the average worker and 0.048 fatal cancer could result among all workers.

E.2.5.2 Tritium Supply Technologies and Recycling

For the tritium supply technologies and recycling facilities, the impacts from the No Action facilities need to be added to the impacts from the tritium supply technologies and recycling facilities to determine the impacts from total site operation. For

example, to determine the radiological impact for the addition of an HWR at NTS, the doses from No Action facilities would be summed with the HWR doses (which includes tritium target extraction) and the tritium recycling doses. Estimated annual atmospheric radioactive releases for the tritium supply technologies and recycling facilities are given in section E.2.3. Tables E.2.5.1-2 and E.2.5.1-3 present the radiological impacts by tritium supply technology and recycling facility. There are no

radioactive liquid releases to the offsite environment associated with this alternative.

The annual doses from total site operation associated with the different tritium supplies ranged from 0.12 to 0.40 mrem to the maximally exposed individual and from 0.1 to 0.24 person-rem to the 50-mile population in the year 2030. The health effects from 40 years of operation are included in both tables.

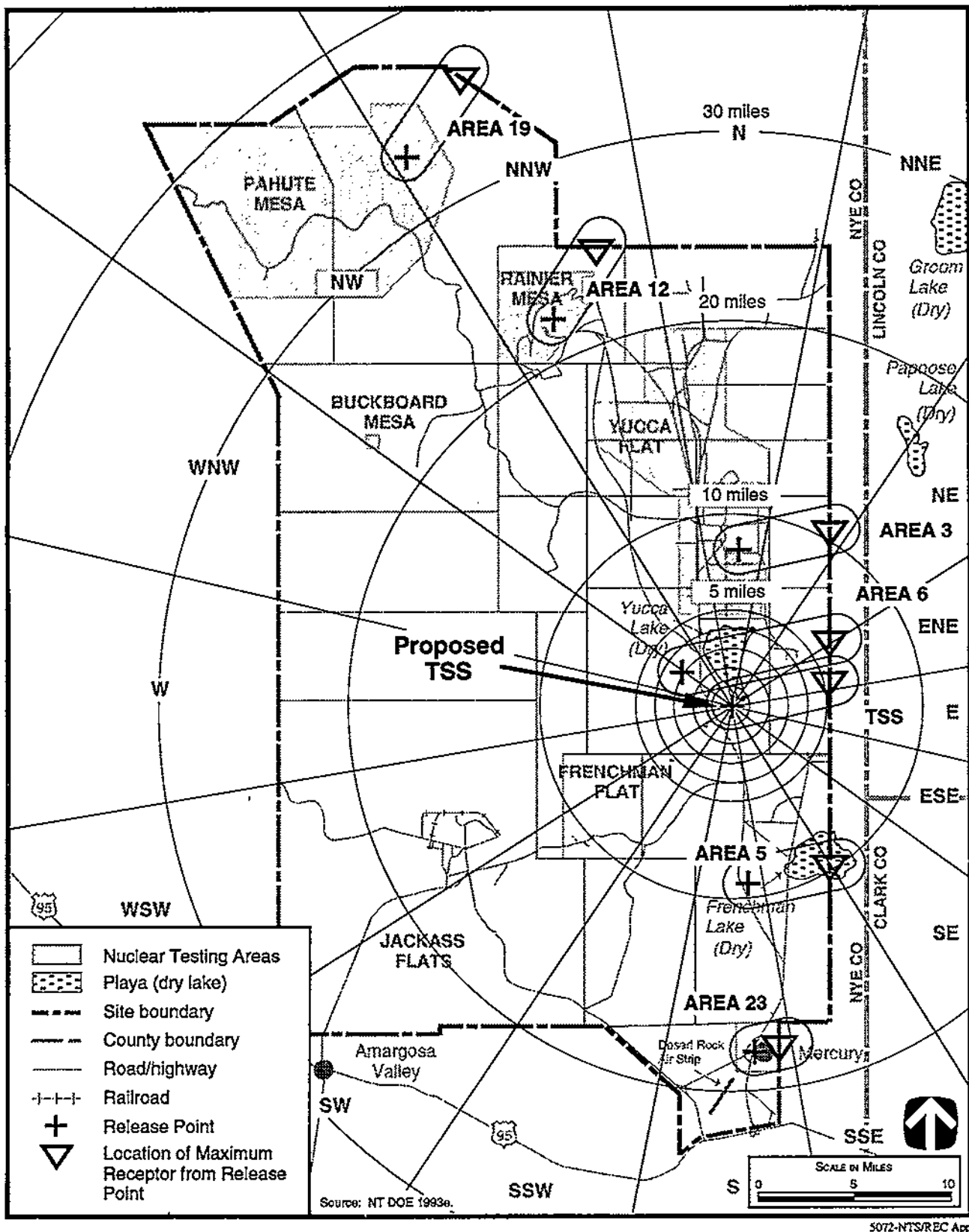


FIGURE E.2.5-1.—Location of Maximum Receptors at Nevada Test Site.

TABLE E.2.5-1.—Release Point Characteristics, Direction, Distance, and Chi/Q at Nevada Test Site Boundary [Page 1 of 2]

Release Point ^a		Area 3		Area 5		Area 6		Area 12	
Latitude		37°1'36.12"		36°46'47.64"		36°56'816"		37°11'48.48"	
Longitude		-116°0'39.25"		-116°0'10.08"		-116°4'623"		-116°11'10.69"	
Release Height:		Ground Level		Ground Level		Ground Level		Ground Level	
Direction	Distance (m)	Chi/Q (s/m ³)	Distance (m)	Chi/Q (s/m ³)	Distance (m)	Chi/Q (s/m ³)	Distance (m)	Chi/Q (s/m ³)	Distance (m)
N.	24,166	8.7x10 ⁻⁹	32,405	5.9x10 ⁻⁹	34,911	5.4x10 ⁻⁹	5,451	6.5x10 ⁻⁸	
NNE.	13,134	2.1x10 ⁻⁸	11,810	2.5x10 ⁻⁸	22,182	1.1x10 ⁻⁸	5,569	6.9x10 ⁻⁸	
NE.	8,858	4.8x10 ⁻⁸	7,952	5.6x10 ⁻⁸	14,928	2.4x10 ⁻⁸	6,606	7.3x10 ⁻⁸	
ENE.	7,522	5.3x10 ⁻⁸	6,753	6.1x10 ⁻⁸	12,727	2.6x10 ⁻⁸	9,858	3.7x10 ⁻⁸	
E.	7,392	5.2x10 ⁻⁸	6,632	6.0x10 ⁻⁸	12,500	2.5x10 ⁻⁸	22,944	1.1x10 ⁻⁸	
ESE.	7,562	4.2x10 ⁻⁸	6,783	4.9x10 ⁻⁸	12,775	2.0x10 ⁻⁸	23,454	9.1x10 ⁻⁹	
SE.	8,969	3.1x10 ⁻⁸	8,078	3.5x10 ⁻⁸	15,148	1.5x10 ⁻⁸	27,813	6.7x10 ⁻⁹	
SSE.	13,549	1.9x10 ⁻⁸	12,243	2.2x10 ⁻⁸	22,834	9.7x10 ⁻⁹	42,052	4.4x10 ⁻⁹	
S.	39,154	6.0x10 ⁻⁹	12,279	2.8x10 ⁻⁸	30,398	8.4x10 ⁻⁹	58,365	3.6x10 ⁻⁹	
SSW.	41,092	6.2x10 ⁻⁹	17,496	1.9x10 ⁻⁸	30,294	9.2x10 ⁻⁹	40,688	6.3x10 ⁻⁹	
SW.	46,379	6.6x10 ⁻⁹	17,352	2.4x10 ⁻⁸	36,377	9.0x10 ⁻⁹	27,188	1.3x10 ⁻⁸	
WSW.	39,124	5.7x10 ⁻⁹	22,735	1.2x10 ⁻⁸	34,550	6.8x10 ⁻⁹	23,618	1.1x10 ⁻⁸	
W.	38,373	8.3x10 ⁻⁹	39,856	7.9x10 ⁻⁹	33,894	9.8x10 ⁻⁹	24,146	1.5x10 ⁻⁸	
WNW.	39,139	8.4x10 ⁻⁹	40,669	7.9x10 ⁻⁹	34,562	9.8x10 ⁻⁹	27,927	1.3x10 ⁻⁸	
NW.	46,438	3.8x10 ⁻⁹	48,027	3.7x10 ⁻⁹	40,791	4.5x10 ⁻⁹	23,860	9.0x10 ⁻⁹	
NNW.	24,654	3.8x10 ⁻⁹	53,210	1.4x10 ⁻⁹	35,691	2.4x10 ⁻⁹	16,125	6.7x10 ⁻⁹	

TABLE E.2.5-1.—Release Point Characteristics, Direction, Distance, and Chi/Q at Nevada Test Site Boundary [Page 2 of 2]

Release Point ^a	Area 19		Area 23		Tritium Supply and Recycling Site	
	Latitude	Longitude	Distance (m)	Chi/Q (s/m ³)	Distance (m)	Chi/Q (s/m ³)
Release Height:	37°18'51.84"	-116°19'20.29"	Ground Level	Ground Level	36°53'42.36"	-116°2'54.96"
			Ground Level	Ground Level	10 meters	
Direction	Distance (m)	Chi/Q (s/m ³)	Distance (m)	Chi/Q (s/m ³)	Accident	
					Annual Average Chi/Q (s/m ³)	Percentile Chi/Q (s/m ³)
N.	6,883	4.7x10 ⁻⁸	30,320	6.5x10 ⁻⁹	5.0x10 ⁻⁹	2.5x10 ⁻⁸
NNE.	7,027	5.0x10 ⁻⁸	11,023	2.7x10 ⁻⁸	1.9x10 ⁻⁸	4.5x10 ⁻⁸
NE.	7,397	6.2x10 ⁻⁸	1,993	4.5x10 ⁻⁷	4.2x10 ⁻⁸	6.9x10 ⁻⁸
ENE.	8,018	4.8x10 ⁻⁸	1,652	5.2x10 ⁻⁷	4.6x10 ⁻⁸	1.1x10 ⁻⁷
E.	10,447	3.2x10 ⁻⁸	1,607	5.0x10 ⁻⁷	4.5x10 ⁻⁸	1.7x10 ⁻⁷
ESE.	12,243	2.2x10 ⁻⁸	1,629	4.1x10 ⁻⁷	3.7x10 ⁻⁸	5.7x10 ⁻⁷
SE.	42,415	3.9x10 ⁻⁹	1,899	3.0x10 ⁻⁷	2.7x10 ⁻⁸	1.0x10 ⁻⁶
SSE.	64,080	2.5x10 ⁻⁹	2,827	1.8x10 ⁻⁷	1.7x10 ⁻⁸	4.7x10 ⁻⁷
S.	53,585	4.0x10 ⁻⁹	6,501	6.8x10 ⁻⁸	9.7x10 ⁻⁹	1.0x10 ⁻⁷
SSW.	20,987	1.5x10 ⁻⁸	7,059	6.5x10 ⁻⁸	9.6x10 ⁻⁹	3.1x10 ⁻⁸
SW.	18,429	2.2x10 ⁻⁸	7,785	7.0x10 ⁻⁸	1.0x10 ⁻⁸	3.4x10 ⁻⁸
WSW.	18,295	1.6x10 ⁻⁸	7,558	5.3x10 ⁻⁸	5.8x10 ⁻⁹	1.1x10 ⁻⁷
W.	12,833	3.6x10 ⁻⁸	9,118	5.7x10 ⁻⁸	8.4x10 ⁻⁹	9.9x10 ⁻⁸
WNW.	8,875	6.0x10 ⁻⁸	41,220	7.8x10 ⁻⁹	8.4x10 ⁻⁹	6.3x10 ⁻⁸
NW.	8,117	3.9x10 ⁻⁸	48,728	3.6x10 ⁻⁹	3.8x10 ⁻⁹	3.8x10 ⁻⁸
NNW.	7,018	2.1x10 ⁻⁸	67,499	1.0x10 ⁻⁹	2.2x10 ⁻⁹	4.5x10 ⁻⁸

^a See figure 4.3.2.1-1 for location of release points.

Source: HNUS 1995a.

TABLE E.2.5-2.—Direction, Distance, and Meteorological Dispersion to Various Maximum Individual Receptors at Nevada Test Site Boundary [Page 1 of 2]

	Direction	Distance (m)	Maximum Receptor For:	Atmospheric Dispersion Chi/Q (sec/m ³)
Release Point: Area 3				
	ENE.	7,522	Area 3	5.3x10 ⁻⁸
	SSE.	27,103	Area 5	7.8x10 ⁻⁹
	SE.	10,672	Area 6	2.4x10 ⁻⁸
	NNW.	27,004	Area 12	3.4x10 ⁻⁹
	NNW.	44,680	Area 19	1.8x10 ⁻⁹
	SE.	13,243	Tritium Supply Site	1.8x10 ⁻⁸
	S.	41,158	Area 23	5.6x10 ⁻⁹
Release Point: Area 5				
	NNE.	29,543	Area 3	7.5x10 ⁻⁹
	ENE.	6,752	Area 5	6.1x10 ⁻⁸
	NNE.	20,762	Area 6	1.2x10 ⁻⁸
	NNW.	53,166	Area 12	1.4x10 ⁻⁹
	NNW.	69,742	Area 19	1.0x10 ⁻⁹
	NNE.	17,680	Tritium Supply Site	1.4x10 ⁻⁸
	S.	13,841	Area 23	2.4x10 ⁻⁸
Release Point: Area 6				
	NE.	17,000	Area 3	2.0x10 ⁻⁸
	SE.	20,273	Area 5	1.0x10 ⁻⁸
	ENE.	12,727	Area 6	2.6x10 ⁻⁸
	NNW.	35,041	Area 12	2.4x10 ⁻⁹
	NNW.	51,517	Area 19	1.5x10 ⁻⁹
	E.	12,532	Tritium Supply Site	2.5x10 ⁻⁸
	SSE.	31,953	Area 23	6.3x10 ⁻⁹
Release Point: Area 12				
	SE.	28,863	Area 3	6.4x10 ⁻⁹
	SSE.	50,480	Area 5	3.5x10 ⁻⁹
	SE.	35,133	Area 6	4.9x10 ⁻⁹
	NE.	6,605	Area 12	7.3x10 ⁻⁸
	NNW.	20,708	Area 19	4.8x10 ⁻⁹
	SE.	37,683	Tritium Supply Site	4.5x10 ⁻⁹
	SSE.	62,700	Area 23	2.6x10 ⁻⁹

TABLE E.2.5-2.—Direction, Distance, and Meteorological Dispersion to Various Maximum Individual Receptors at Nevada Test Site Boundary [Page 2 of 2]

	Direction	Distance (m)	Maximum Receptor For:	Atmospheric Dispersion Chi/Q (s/m ³)
Release Point: Area 19				
	SE.	46,455	Area 3	3.4x10 ⁻⁹
	SSE.	67,757	Area 5	2.4x10 ⁻⁹
	SE.	52,890	Area 6	2.9x10 ⁻⁹
	ESE.	17,575	Area 12	1.3x10 ⁻⁸
	NE.	7,396	Area 19	6.2x10 ⁻⁸
	SE.	55,398	Tritium Supply Site	2.8x10 ⁻⁹
	SSE.	79,095	Area 23	1.9x10 ⁻⁹
Release Point: Tritium Supply Site				
	NNE.	16,170	Area 3	1.6x10 ⁻⁸
	SSE.	15,807	Area 5	1.6x10 ⁻⁸
	ENE.	9,495	Area 6	3.8x10 ⁻⁸
	NNW.	38,441	Area 12	2.2x10 ⁻⁹
	NNW.	55,421	Area 19	1.4x10 ⁻⁹
	ENE.	8,319	Tritium Supply Site	4.6x10 ⁻⁸
	S.	28,747	Area 23	9.0x10 ⁻⁹
Release Point: Area 23				
	N.	43,225	Area 3	4.1x10 ⁻⁹
	NNE.	16,488	Area 5	1.6x10 ⁻⁸
	N.	34,229	Area 6	5.5x10 ⁻⁹
	NNW.	66,933	Area 12	1.1x10 ⁻⁹
	NNW.	83,144	Area 19	8.1x10 ⁻¹⁰
	N.	31,002	Tritium Supply Site	6.3x10 ⁻⁹
	ENE.	1,651	Area 23	5.2x10 ⁻⁷

Source: HNUS 1995a.

TABLE E.2.5.1-1.—Estimated Annual Atmospheric Radioactive Releases from Normal Operation of No Action at Nevada Test Site (curies)

Isotope	Area 3	Area 5	Area 6	Area 12	Area 19	Area 23
H-3	0	0.6	4.8×10^{-3}	2.2×10^3	0	5.1×10^{-4}
Ar-37	0	0	0	0	0	0
Ar-39	0	0	0	0	0	0
Kr-85	0	0	0	0	280	0
Xe-127	0	0	0	0	0	0
Xe-129	0	0	0	0	0	0
Xe-131	0	0	0	0	0	0
Xe-133	0	0	0	0	0	0.04
I-131	0	0	1.3×10^{-5}	0	0	5.8×10^{-5}
Pu-239	2.5×10^{-3}	0	0	0	0	0
U-234	0	0	0	0	0	0
U-235	0	0	0	0	0	0
U-238	0	0	0	0	0	0

Note: For reconfiguration, Device Assembly Facility upgrade assumed to be equivalent to the assembly, disassembly and high explosion upgrade at Pantex.

Source: NTS 1993a:4; table E.2.7-2.

TABLE E.2.5.1-2.—Doses and Resulting Health Effect to the Maximally Exposed Individual Resulting from Normal Operation at Nevada Test Site

Alternative	Dose by Pathway (mrem per year)					Committed Effective Dose Equivalent (mrem per year)	Percent of Background ^a	Estimated 40-Year Fatal Cancer Risk
	Inhalation	Ingestion	Immersion	Ground Shine	Plume			
No Action	3.2x10 ⁻³	0.038	1.5x10 ⁻⁶	1.1x10 ⁻⁹		0.04	0.013	8.1x10 ⁻⁷
No Action Contribution to Tritium Supply Site Maximum Receptor	2.8x10 ⁻³	2.3x10 ⁻³	3.0x10 ⁻⁷	8.0x10 ⁻⁹		5.1x10 ⁻³	1.6x10 ⁻³	1.0x10 ⁻⁷
Heavy Water Reactor	0.039	0.14	4.8x10 ⁻⁴	1.8x10 ⁻⁴		0.19	0.059	3.7x10 ⁻⁶
Modular High Temperature Gas-Cooled Reactor	5.5x10 ⁻³	0.075	1.2x10 ⁻⁴	5.6x10 ⁻⁵		0.081	0.026	1.6x10 ⁻⁶
Advanced Boiling Water Reactor	0.017	0.25	5.1x10 ⁻³	8.0x10 ⁻⁴		0.28	0.087	5.5x10 ⁻⁶
CE System 80+	0.017	0.24	6.0x10 ⁻⁴	3.4x10 ⁻⁴		0.27	0.084	5.3x10 ⁻⁶
Simplified Boiling Water Reactor	0.017	0.25	1.3x10 ⁻³	1.9x10 ⁻³		0.28	0.087	5.5x10 ⁻⁶
AP600	0.017	0.24	1.7x10 ⁻³	5.2x10 ⁻⁴		0.27	0.084	5.3x10 ⁻⁶
Full Accelerator Production of Tritium with helium-3	2.0x10 ⁻⁴	2.7x10 ⁻³	1.4x10 ⁻⁵	7.0x10 ⁻⁹		2.9x10 ⁻³	9.2x10 ⁻⁴	5.8x10 ⁻⁸
Full Accelerator Production of Tritium with spallation-induced lithium conversion	3.9x10 ⁻³	0.053	1.4x10 ⁻⁵	7.0x10 ⁻⁹		0.057	0.018	1.1x10 ⁻⁶
Phased Accelerator Production of Tritium	2.0x10 ⁻⁴	2.7x10 ⁻³	7.2x10 ⁻⁶	3.6x10 ⁻⁹		2.9x10 ⁻³	9.2x10 ⁻⁴	5.8x10 ⁻⁸
Tritium Recycling	7.9x10 ⁻³	0.11	7.2x10 ⁻¹²	0		0.12	0.038	2.4x10 ⁻⁶

^a Individual annual natural background radiation dose is equal to 317 mrem.

Source: HNUS 1995a.

TABLE E.2.5.1-3.—Doses and Resulting Health Effect to the Population Within 50 Miles Resulting from Normal Operation at Nevada Test Site

Alternative	Dose by Pathway in 2030 (person-rem)					Committed Effective Dose Equivalent in 2030 (person-rem)	Percent of Background ^a	Estimated 40-Year Fatal Cancers
	Inhalation	Ingestion	Plume Immersion	Ground Shine				
No Action	4.3x10 ⁻³	3.9x10 ⁻³	1.1x10 ⁻⁵	5.5x10 ⁻⁹		8.2x10 ⁻³	1.4x10 ⁻⁴	1.6x10 ⁻⁴
Heavy Water Reactor	0.035	0.083	2.4x10 ⁻⁴	1.7x10 ⁻⁴		0.12	2.0x10 ⁻³	2.4x10 ⁻³
Modular High Temperature Gas-Cooled Reactor	4.9x10 ⁻³	0.045	5.8x10 ⁻⁵	3.9x10 ⁻⁵		0.051	8.7x10 ⁻⁴	1.0x10 ⁻³
Advanced Boiling Water Reactor	0.014	0.15	1.4x10 ⁻³	5.5x10 ⁻⁴		0.16	2.8x10 ⁻³	3.3x10 ⁻³
CE System 80+	0.014	0.14	3.2x10 ⁻⁴	3.0x10 ⁻⁴		0.16	2.6x10 ⁻³	3.1x10 ⁻³
Simplified Boiling Water Reactor	0.014	0.16	4.6x10 ⁻⁴	1.6x10 ⁻³		0.17	3.0x10 ⁻³	3.5x10 ⁻³
AP600	0.014	0.15	1.1x10 ⁻³	4.5x10 ⁻⁴		0.16	2.8x10 ⁻³	3.3x10 ⁻³
Full Accelerator Production of Tritium with SILC	3.4x10 ⁻³	0.031	7.1x10 ⁻⁶	6.7x10 ⁻¹³		0.035	6.0x10 ⁻⁴	7.0x10 ⁻⁴
Full Accelerator Production of Tritium with helium-3	1.7x10 ⁻⁴	1.6x10 ⁻³	7.6x10 ⁻⁶	6.7x10 ⁻¹³		1.8x10 ⁻³	3.1x10 ⁻⁵	3.6x10 ⁻⁵
Phased Accelerator Production of Tritium	1.7x10 ⁻⁴	1.6x10 ⁻³	3.6x10 ⁻⁶	3.4x10 ⁻¹³		1.8x10 ⁻³	3.1x10 ⁻⁵	3.6x10 ⁻⁵
Tritium Recycling	6.9x10 ⁻³	0.063	6.4x10 ⁻¹²	0		0.07	1.2x10 ⁻³	1.4x10 ⁻³

^a Dose to the population within 50 miles from natural background radiation in year 2030 is equal to 5,860 person-rem.
Source: HNUUS 1995a.

E.2.6 Radiological Impacts at Oak Ridge Reservation

This section presents the radiological impacts of the tritium supply technologies and recycling facilities at ORR. Section E.2.6.1 presents the radiological releases and resulting impacts from facilities associated with No Action. Section E.2.6.2 presents the radiological releases and resulting impacts from the facilities associated with the tritium supply technologies and recycling facilities.

For purposes of radiological impact modeling, ORR was divided into six areas. All potential release points in each area were aggregated into a single release point. Table E.2.6-1 presents the characteristics of each of the release points including location, release height, minimum distance, and annual average dispersion to the site boundary in each of 16 directions. In order to calculate the maximum site boundary dose, the dose from each release point to the maximum receptor associated with each of the other release points has been calculated. For example, the dose resulting from releases from the Oak Ridge National Laboratory, Y-12 Plant, Advanced Neutron Source Reactor, High Flux Isotope Reactor areas, and the proposed TSS has been determined for the maximum receptor from the K-25 incinerator. Figure E.2.6-1 illustrates the location of each maximum receptor in relation to each release point. The maximum site boundary dose is then determined by the maximum dose of each of the maximum receptors. Table E.2.6-2 presents the distance, direction, and atmospheric dispersion from each release point to each of the maximum receptors. Annual radiological releases were assumed to remain constant during the 40-year operation period.

Descriptions of population, food stuffs distributions, and aquatic foods for each release area are provided in the *Health Risk Data* report. The joint frequency distributions used for the dose assessment were based on 1990 meteorological measurements from five meteorological towers (Tower 1 for K-25, Tower 2 for Oak Ridge National Laboratory, Tower 4 for Advanced Neutron Source Reactor, High Flux Isotope Reactor and Radiochemical Engineering Development Center, Tower 5 for Y-12, and Tower 6 for the proposed TSS location) at the 10 meter height and are contained in a technical report (*Health Risk Data*, HNUS 1995a).

Doses given in this section are associated with 1 year of operation because regulatory standards are given as annual limits. The health effects presented are for a 40-year operational period.

E.2.6.1 No Action

Atmospheric Releases. For No Action, five of the areas have radioactive releases into the atmosphere from normal operation. Table E.2.6.1-1 presents the estimated annual atmospheric radioactive releases.

Tables E.2.6.1-2 and E.2.6.1-3 include the atmospheric radiological impacts to the maximally exposed member of the public and the offsite population within 50 miles, respectively. The maximally exposed individual would receive an annual dose of 3.9 mrem. An estimated fatal cancer risk of 7.8×10^{-5} would result from 40 years of operation. The population within 50 miles would receive a dose of 39 person-rem in the year 2030 (midlife of operation). An estimated 0.78 fatal cancers could result from 40 years of operation.

Liquid Releases. For No Action, some areas may have radioactive releases to the offsite surface water from normal operation. Table E.2.6.1-4 presents the estimated annual liquid radioactive releases.

Tables E.2.6.1-5 and E.2.6.1-6, respectively, present the radiological impacts to the maximally exposed individual and the offsite populations using surface water within 50 miles downstream of ORR. The maximally exposed member of the public would receive an annual dose of 14 mrem. An estimated fatal cancer risk of 2.7×10^{-4} would result from 40 years of operation. The population would receive a dose of 18 person-rem in the year 2030. An estimated 0.36 fatal cancers could result from 40 years of operation.

Worker Doses. Based on measured values during 1991 and 1992 (Dose Reports for 1991 and 1992) and including the contribution from the Advanced Neutron Source Reactor, it is estimated that the average dose to a badged worker involved in No Action activities at ORR in the year 2010 and beyond would equal 17.4 mrem. It is projected that in the year 2010 and beyond, there would be 18,315 badged workers involved in No Action activities. The annual dose among all these workers would equal

319 person-rem. From 40 years of operation, an estimated fatal cancer risk of 2.8×10^{-4} would result to the average worker and 5.1 fatal cancers could result among all workers.

E.2.6.2 Tritium Supply Technologies and Recycling

Atmospheric Releases. For the tritium supply technologies and recycling facilities, total site radiological impacts resulting from tritium supply technologies and recycling facilities can be found by adding the impacts resulting from No Action facilities to those resulting from each tritium supply technology and recycling facility. For example, to determine the radiological impact for the addition of the HWR at ORR, the No Action facilities impacts would be summed with the HWR doses (which includes tritium target extraction) and the tritium recycling dose. Estimated annual atmospheric radioactive releases for the tritium supply technologies and recycling facilities are given in section E.2.3. Tables E.2.6.1-2 and E.2.6.1-3 present the atmospheric radiological impacts by tritium supply technology and recycling facility.

The annual dose from total site operation associated with the different tritium supplies ranged from 4.3 to 5.0 mrem to the maximally exposed member of the public and from 50 to 70 person-rem to the 50-mile population in the year 2030. The health effects from 40 years of operation are included in both tables.

Liquid Releases. There are three technologies that would release liquid discharges to the surface water surrounding ORR. These are the HWR and the Large and Small ALWRs. The liquid releases for these two technologies are given in section E.2.3. For example, to determine the liquid radiological impact for the addition of an HWR at ORR, the No Action liquid impacts must be summed with the HWR liquid doses. Tables E.2.6.1-5 and E.2.6.1-6 present the liquid radiological impacts for the applicable alternatives.

The annual doses from total site operations associated with the different tritium supplies that have liquid releases are all approximately 14 mrem to the maximally exposed member of the public, and ranged from 18 to 23 person-rem to the downstream population in the year 2030. The health effects from 40 years of operation are included in both tables.



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TABLE E.2.6-1.—Release Point Characteristics, Direction, Distance, and Chi/Q at Oak Ridge Reservation Boundary [Page 1 of 2]

Release Point ^a		K-25 Incinerator		ORNL (3039 Stack)		Y-12 Plant		REDC	
Latitude		35°56'15.36"		35°55'39.01"		35°59'08.52"		35°55'08.04"	
Longitude		-84°22'54.83"		-84°18'55.44"		-84°15'38.51"		-84°18'12.95"	
Release Height:		30.5 meters		76.2 meters		20.0 meters		76.2 meters	
Direction		Distance (meter)	Chi/Q (sec/m ³)	Distance (meter)	Chi/Q (sec/m ³)	Distance (meter)	Chi/Q (sec/m ³)	Distance (meter)	Chi/Q (sec/m ³)
N.		3,042	3.5x10 ⁻⁷	4,202	1.0x10 ⁻⁷	683	1.1x10 ⁻⁶	5,838	4.5x10 ⁻⁸
NNE.		3,933	4.1x10 ⁻⁷	5,845	1.8x10 ⁻⁷	888	1.5x10 ⁻⁶	7,329	1.1x10 ⁻⁷
NE.		4,361	5.3x10 ⁻⁷	8,512	1.9x10 ⁻⁷	1,628	8.1x10 ⁻⁷	3,381	7.1x10 ⁻⁷
ENE.		4,634	3.4x10 ⁻⁷	3,933	6.1x10 ⁻⁷	2,336	4.6x10 ⁻⁷	3,440	7.5x10 ⁻⁷
E.		9,767	7.1x10 ⁻⁸	4,358	3.5x10 ⁻⁷	2,964	3.7x10 ⁻⁷	3,122	5.6x10 ⁻⁷
ESE.		9,644	6.0x10 ⁻⁸	4,390	1.9x10 ⁻⁷	2,283	1.4x10 ⁻⁷	3,046	2.2x10 ⁻⁷
SE.		4,924	1.9x10 ⁻⁷	4,029	1.5x10 ⁻⁷	2,329	8.1x10 ⁻⁸	2,595	1.6x10 ⁻⁷
SSE.		2,307	5.3x10 ⁻⁷	4,358	1.5x10 ⁻⁷	3,728	8.2x10 ⁻⁸	2,913	8.6x10 ⁻⁸
S.		2,418	4.1x10 ⁻⁷	4,299	2.5x10 ⁻⁷	4,682	6.1x10 ⁻⁸	3,350	8.5x10 ⁻⁸
SSW.		3,303	2.9x10 ⁻⁷	3,752	4.0x10 ⁻⁷	9,615	4.2x10 ⁻⁸	3,449	1.6x10 ⁻⁷
SW.		3,897	4.2x10 ⁻⁷	3,755	2.8x10 ⁻⁷	11,872	1.1x10 ⁻⁷	3,626	5.0x10 ⁻⁷
WSW.		2,894	6.4x10 ⁻⁷	5,054	2.6x10 ⁻⁷	3,442	5.3x10 ⁻⁷	3,895	6.2x10 ⁻⁷
W.		3,619	1.7x10 ⁻⁷	8,677	5.8x10 ⁻⁸	1,074	7.7x10 ⁻⁷	5,945	1.0x10 ⁻⁷
WNW.		2,782	1.6x10 ⁻⁷	7,260	2.7x10 ⁻⁸	806	5.5x10 ⁻⁷	8,636	2.2x10 ⁻⁸
NW.		2,356	2.2x10 ⁻⁷	4,464	4.6x10 ⁻⁸	686	6.5x10 ⁻⁷	5,267	3.2x10 ⁻⁸
NNW.		1,857	3.0x10 ⁻⁷	3,900	7.8x10 ⁻⁸	620	8.1x10 ⁻⁷	5,262	3.5x10 ⁻⁸

TABLE E.2.6-1.—Release Point Characteristics, Direction, Distance, and Chi/Q at Oak Ridge Reservation Boundary [Page 2 of 2]

Release Point ^a		Tritium Supply and Recycling Site	
Latitude	35°55'32.52"	35°55'59.17"	
Longitude	-84°17'31.20"	-84°20'55.68"	
Release Height:	10.0 meters	Ground Level	

Direction	Distance (meter)	Chi/Q (sec/m ³)	Distance (meter)	Accident		
				Annual Chi/Q (sec/m ³)	50 Percentile Chi/Q (s/m ³)	95 Percentile Chi/Q (s/m ³)
N.	5,859	4.5x10 ⁻⁸	3,199	2.2x10 ⁻⁷	1.8x10 ⁻⁵	1.3x10 ⁻⁴
NNE.	6,940	1.2x10 ⁻⁷	2,993	5.8x10 ⁻⁷	1.9x10 ⁻⁵	1.7x10 ⁻⁴
NE.	2,091	1.5x10 ⁻⁶	4,638	6.2x10 ⁻⁷	1.6x10 ⁻⁵	8.4x10 ⁻⁵
ENE.	2,124	1.6x10 ⁻⁶	9,495	2.9x10 ⁻⁷	5.8x10 ⁻⁶	3.1x10 ⁻⁵
E.	2,815	6.6x10 ⁻⁷	6,807	1.5x10 ⁻⁷	6.4x10 ⁻⁶	3.6x10 ⁻⁵
ESE.	2,483	3.0x10 ⁻⁷	6,781	1.2x10 ⁻⁷	5.8x10 ⁻⁶	2.6x10 ⁻⁵
SE.	2,465	1.8x10 ⁻⁷	5,908	6.9x10 ⁻⁸	7.6x10 ⁻⁶	2.9x10 ⁻⁵
SSE.	2,679	9.9x10 ⁻⁸	3,577	6.0x10 ⁻⁸	9.0x10 ⁻⁶	3.5x10 ⁻⁵
S.	3,172	9.3x10 ⁻⁸	3,418	8.7x10 ⁻⁸	1.1x10 ⁻⁵	5.2x10 ⁻⁵
SSW.	4,311	1.1x10 ⁻⁷	3,098	4.5x10 ⁻⁷	1.9x10 ⁻⁵	1.1x10 ⁻⁴
SW.	4,903	3.2x10 ⁻⁷	2,903	1.1x10 ⁻⁶	2.0x10 ⁻⁵	1.5x10 ⁻⁴
WSW.	5,215	4.0x10 ⁻⁷	4,900	2.1x10 ⁻⁷	9.7x10 ⁻⁶	8.0x10 ⁻⁵
W.	7,350	7.5x10 ⁻⁸	5,700	5.6x10 ⁻⁸	6.8x10 ⁻⁶	5.7x10 ⁻⁵
WNW.	8,891	2.1x10 ⁻⁸	4,294	4.7x10 ⁻⁸	6.2x10 ⁻⁶	5.7x10 ⁻⁵
NW.	5,174	3.3x10 ⁻⁸	4,787	3.9x10 ⁻⁸	5.1x10 ⁻⁶	5.4x10 ⁻⁵
NNW.	5,181	3.6x10 ⁻⁸	4,770	4.7x10 ⁻⁸	3.5x10 ⁻⁶	4.1x10 ⁻⁵

^a See figure 4.4-2 for location of release points.Note: ORNL - Oak Ridge National Laboratory; REDC - Radiochemical Engineering Development Center; ANSR - Advanced Neutron Source Reactor.
Source: HINUS 1995a.

TABLE E.2.6-2.—Direction, Distance, and Meteorological Dispersion to Various Maximum Individual Receptors at Oak Ridge Reservation Site Boundary

	Direction	Distance (m)	Maximum Receptor For:	Atmospheric Dispersion Chi/Q (sec/m ³)
Release Point: K-25 Incinerator				
	WSW.	2894.	K-25 Incinerator	6.4x10 ⁻⁷
	E.	9784	Oak Ridge National Laboratory 3039 Stack	7.1x10 ⁻⁸
	ENE.	12748	Y-12 Plant	7.8x10 ⁻⁸
	E.	9993	High Flux Isotope Reactor Stack	6.9x10 ⁻⁸
	SSE.	2307	Tritium Supply Site	5.3x10 ⁻⁷
	E.	9916	Advanced Neutron Source Reactor	7.0x10 ⁻⁸
Release Point: X-10 ORNL				
	W.	8756	K-25 Incinerator	5.7x10 ⁻⁸
	ENE.	3933	Oak Ridge National Laboratory 3039 Stack	6.1x10 ⁻⁷
	NNE.	8943	Y-12 Plant	9.7x10 ⁻⁸
	ENE.	4083	High Flux Isotope Reactor Stack	5.7x10 ⁻⁷
	WSW.	5407	Tritium Supply Site	2.3x10 ⁻⁷
	ENE.	4023	Advanced Neutron Source Reactor	5.9x10 ⁻⁷
Release Point: Y-12 Plant				
	WSW.	15037	K-25 Incinerator	7.2x10 ⁻⁸
	S.	5508	Oak Ridge National Laboratory 3039 Stack	4.8x10 ⁻⁸
	NNE.	887	Y-12 Plant	1.5x10 ⁻⁶
	S.	5676	High Flux Isotope Reactor Stack	4.6x10 ⁻⁸
	SW.	12769	Tritium Supply Site	9.6x10 ⁻⁸
	S.	5625	Advanced Neutron Source Reactor	4.7x10 ⁻⁸
Release Point: HFIR Stack				
	W.	9896	K-25 Incinerator	4.9x10 ⁻⁸
	NE.	3389	Oak Ridge National Laboratory 3039 Stack	7.0x10 ⁻⁷
	NNE.	9225	Y-12 Plant	8.0x10 ⁻⁸
	ENE.	3440	High Flux Isotope Reactor Stack	7.5x10 ⁻⁷
	W.	6431	Tritium Supply Site	9.2x10 ⁻⁸
	NE.	3412	Advanced Neutron Source Reactor	7.0x10 ⁻⁷
Release Point: Tritium Supply Site				
	W.	5750	K-25 Incinerator	5.5x10 ⁻⁸
	E.	6817	Oak Ridge National Laboratory 3039 Stack	1.5x10 ⁻⁷
	NE.	10558	Y-12 Plant	1.9x10 ⁻⁷
	E.	7012	High Flux Isotope Reactor Stack	1.5x10 ⁻⁷
	SW.	2903	Tritium Supply Site	1.1x10 ⁻⁶
	E.	6939	Advanced Neutron Source Reactor	1.5x10 ⁻⁷
Release Point: ANS Reactor				
	W.	10875	K-25 Incinerator	4.2x10 ⁻⁸
	NE.	2098	Oak Ridge National Laboratory 3039 Stack	1.5x10 ⁻⁶
	NNE.	8104	Y-12 Plant	9.7x10 ⁻⁸
	ENE.	2156	High Flux Isotope Reactor Stack	1.6x10 ⁻⁶
	W.	7526	Tritium Supply Site	7.3x10 ⁻⁸
	ENE.	2124	Advanced Neutron Source Reactor	1.6x10 ⁻⁶

Source: HNUS 1995a.

TABLE E.2.6.1-1.—Annual Atmospheric Radioactive Releases from Normal Operation of No Action at Oak Ridge Reservation (curies) [Page 1 of 2]

Isotope	ANSR	K-25 Incinerator	ORNL	REDC ^a	Y-12 Plant
H-3	7.2x10 ³	0	1.6x10 ⁴	13	0
Be-7	0	0	6.7x10 ⁻⁶	0	0
Co-57	0	4.1x10 ⁻⁷	0	0	0
Co-60	2.2x10 ⁻⁸	0	2.0x10 ⁻⁴	0	0
Br-82	0	0	8.8x10 ⁻⁴	0	0
Kr-83m	0	0	0	1.9	0
Kr-85	1.8x10 ³	0	4.8x10 ³	230	0
Kr-85m	0	0	0	3.8	0
Kr-87	0	0	0	23	0
Kr-88	0	0	0	17	0
Kr-89	0	0	0	330	0
Kr-90	0	0	0	700	0
Rb-88	0	0	0	13	0
Rb-89	0	0	0	52	0
Rb-90	0	0	0	160	0
Rb-90m	0	0	0	15	0
Sr-89	0	0	0	0.016	0
Sr-90	2.2x10 ⁻⁶	0	3.3x10 ⁻⁵	5.0x10 ⁻⁵	0
Sr-91	0	0	0	0.21	0
Sr-92	0	0	0	1.0x10 ⁻⁵	0
Y-91	0	0	0	7.0x10 ⁻⁴	0
Y-92	0	0	0	1.0x10 ⁻⁵	0
Zr-95	0	0	0	2.0x10 ⁻⁸	0
Nb-95	0	1.5x10 ⁻⁶	0	0	0
Tc-99	0	0.040	0	0	0
Ru-103	0	0	0	6.0x10 ⁻⁸	0
Ru-106	0	0	0	6.0x10 ⁻⁸	0
Ag-110m	0	0	0	1.0x10 ⁻⁹	0
Te-132	1.0x10 ⁻⁵	0	0	0	0
I-129	3.7x10 ⁻⁶	0	4.2x10 ⁻⁶	6.0x10 ⁻⁴	0
I-131	0.13	0	2.1x10 ⁻⁶	0.28	0
I-132	5.4x10 ⁻³	0	0	3.8x10 ⁻²	0
I-133	0.13	0	0	6.6x10 ⁻³	0
I-134	0	0	0	0.23	0
I-135	0.11	0	0	0.030	0
Xe-131m	0	0	0	0.12	0
Xe-133	8.5x10 ³	0	0	380	0
Xe-133m	0	0	0	0.23	0
Xe-135	0	0	0	100	0
Xe-135m	0	0	0	0	0
Xe-137	0	0	0	4.0x10 ³	0
Xe-138	0	0	0	1.7x10 ³	0
Cs-134	0	0	0	2.0x10 ⁻⁹	0
Cs-136	0	0	0	9.0x10 ⁻⁹	0
Cs-137	4.4x10 ⁻⁶	5.5x10 ⁻⁴	6.9x10 ⁻⁵	1.1x10 ⁻³	0
Cs-138	0	0	0	400	0

TABLE E.2.6.1-1.—Annual Atmospheric Radioactive Releases from Normal Operation of No Action at Oak Ridge Reservation (curies) [Page 2 of 2]

Isotope	ANSR	K-25 Incinerator	ORNL	REDC ^a	Y-12 Plant
Cs-139	0	0	0	1.5x10 ³	0
Ba-139	0	0	0	92	0
Ba-140	0	0	0	0.22	0
Ba-141	0	0	0	2.0x10 ⁻⁵	0
La-140	3.0x10 ⁻⁶	0	0	0	0
La-141	0	0	0	1.0x10 ⁻⁶	0
Ce-141	0	0	0	5.0x10 ⁻⁸	0
Ce-144	0	0	4	6.0x10 ⁻⁸	0
Nd-147	0	0	0	2.0x10 ⁻⁸	0
Eu-154	0	0	0	4.0x10 ⁻¹⁰	0
Eu-155	0	0	0	4.0x10 ⁻¹⁰	0
Eu-156	0	0	0	5.0x10 ⁻⁸	0
Tb-160	0	0	0	8.0x10 ⁻¹⁰	0
Os-191	0	0	4.0	0	0
Pb-212	0.057	0	0.22	0	0
Th-228	8.8x10 ⁻⁹	2.7x10 ⁻³	4.2x10 ⁻⁸	0	0
Th-230	1.1x10 ⁻⁸	8.4x10 ⁻⁵	1.3x10 ⁻⁸	0	0
Th-232	7.8x10 ⁻⁹	1.5x10 ⁻⁵	9.6x10 ⁻⁹	0	0
Th-234	0	0.047	0	0	0
U-234	1.6x10 ⁻⁸	0.011	5.3x10 ⁻⁸	0	0.04
U-235	0	4.6x10 ⁻⁴	0	0	1.2x10 ⁻³
U-236	0	4.0x10 ⁻¹¹	0	0	1.6x10 ⁻⁴
U-238	0	0.013	0	0	5.5x10 ⁻³
Np-237	0	8.1x10 ⁻⁴	0	0	0
Pu-238	0	4.3x10 ⁻⁸	7.3x10 ⁻⁸	4.0x10 ⁻⁹	0
Pu-239	4.3x10 ⁻¹⁰	5.4x10 ⁻⁵	3.6x10 ⁻⁷	5.0x10 ⁻¹⁰	0
Pu-240	0	0	0	9.0x10 ⁻¹⁰	0
Pu-241	0	0	0	1.0x10 ⁻⁷	0
Pu-242	0	0	0	3.0x10 ⁻¹²	0
Cm-244	0	0	0	2.0x10 ⁻⁷	0
Cf-252	0	0	0	1.0x10 ⁻⁸	0

^a The following isotopes were not in GENII. To account for its activity, the isotope's activity was added to its daughter's activity adjusted by the ratio of the daughter-to-parent half-lives. Kr-91 half-life of 8.6 S decays to Rb-91 half-life 1.2 min. Rr-91 half-life of 1.2 M decays to Sr-91 half-life 9.67 hr. I-133M half-life of 9 S decays to I-133 half-life 21 hr. I-136 half-life of 1.39M decays to Xe-136 (stable). I-137 half-life of 24.5 S decays to Cs-137 half-life 30 yr. I-138 half-life of 5.9 S decays to Xe-138 half-life 17 min. Xe-139 half-life of 39.7 S decays to Cs-139 half-life 9.5 min. Xe-140 half-life of 13.6 S decays to Ba-140 half-life 12.8 day. Cs-140 half-life of 1.06 M decays to Ba-140 half-life 12.8 day. Rn-220 half-life of 55.6 S decays to Pb-208 (stable). Bk-243 half-life of 4.5 hr not in GENII. Es-253 half-life of 20.47 day not in GENII.

Note: ANSR - Advanced Neutron Source Reactor; ORNL - Oak Ridge National Laboratory; REDC - Radiochemical Engineering Development Center.

Source: ORR 1993a:8.

TABLE E.2.6.1-2.—Doses and Resulting Health Effect to the Maximally Exposed Individual from Atmospheric Releases Associated with Normal Operation at Oak Ridge Reservation

Alternative	Dose by Pathway (mrem per year)					Committed Effective Dose Equivalent (mrem per year)	Percent of Background ^a	Estimated 40-Year Fatal Cancer Risk
	Inhalation	Ingestion	Plume Immersion	Ground Shine				
No Action – Advanced Neutron Source Reactor	0.34	3	0.55	0.015		3.9	1.3	7.8×10^{-5}
No Action – High Flux Isotope Reactor	1.8	8.4×10^{-3}	0.034	5.3×10^{-4}		1.8	0.59	3.6×10^{-5}
No Action Contribution to Tritium Supply Site Maximum Receptor from Advanced Neutron Source Reactor	0.58	0.16	0.11	2.5×10^{-3}		0.85	0.28	1.7×10^{-5}
No Action Contribution to Tritium Supply Site Maximum Receptor from High Flux Isotope Reactor	0.57	0.017	0.092	1.3×10^{-3}		0.67	0.22	1.3×10^{-5}
Heavy Water Reactor	0.22	3.3	0.013	3.6×10^{-4}		3.5	1.1	7.0×10^{-5}
Modular High Temperature Gas-Cooled Reactor	0.14	1.9	3.2×10^{-3}	1.5×10^{-3}		2	0.66	4.0×10^{-5}
AP600 Reactor	0.13	2.2	0.043	3.8×10^{-3}		2.4	0.78	4.8×10^{-5}
Advanced Boiling Water Reactor	0.27	4.3	0.16	0.017		4.7	1.5	9.4×10^{-5}
CE System 80+	0.33	4.9	0.015	3.5×10^{-4}		5.2	1.7	1.0×10^{-4}
Simplified Boiling Water Reactor	0.23	3.7	0.039	0.043		4	1.3	8.0×10^{-5}
Full Accelerator Production of Tritium with helium-3	4.8×10^{-3}	0.065	4.2×10^{-4}	4.7×10^{-6}		0.07	0.023	1.4×10^{-6}
Full Accelerator Production of Tritium with spallation-induced lithium conversion	0.099	1.3	4.2×10^{-4}	4.7×10^{-6}		1.4	0.46	2.8×10^{-5}
Phased Accelerator Production of Tritium	4.8×10^{-3}	0.065	1.7×10^{-4}	2.4×10^{-7}		0.070	0.023	1.4×10^{-6}
Tritium Recycling	0.19	2.6	1.8×10^{-6}	0		2.8	0.92	5.6×10^{-5}

^a Individual annual natural background radiation dose is equal to 306 mrem.

Source: HNUS 1995a.

TABLE E.2.6.1-3.—Doses and Resulting Health Effect to the Population Within 50 Miles of Oak Ridge Reservation from Atmospheric Releases Associated with Normal Operation

Alternative	Dose by Pathway in 2030 (person-rem)					Committed Effective Dose Equivalent in 2030 (person-rem)	Percent of Background ^a	Estimated 40-Year Fatal Cancers
	Inhalation	Ingestion	Plume Immersion	Ground Shine				
No Action – Advanced Neutron Source Reactor	29	5.4	4.1	0.16		39	0.012	0.77
No Action – High Flux Isotope Reactor	27	0.23	3.9	0.055		31	9.5x10 ⁻³	0.63
AP600 Reactor	2.1	7.1	0.52	0.061		9.8	3.0x10 ⁻³	0.20
Advanced Boiling Water Reactor	4.3	14	0.84	0.21		19	5.6x10 ⁻³	0.37
CE System 80+	5.3	15	0.16	5.5x10 ⁻³		21	6.2x10 ⁻³	0.41
Simplified Boiling Water Reactor	3.7	12	0.25	0.66		17	5.0x10 ⁻³	0.33
Heavy Water Reactor	3.4	10	0.12	5.6x10 ⁻³		14	4.2x10 ⁻³	0.28
Modular High Temperature Gas-Cooled Reactor	2.2	5.7	0.03	0.018		7.9	2.4x10 ⁻³	0.16
Full Accelerator Production of Tritium with spallation-induced lithium conversion	1.5	4	4.0x10 ⁻³	1.7x10 ⁻⁷		5.5	1.7x10 ⁻³	0.11
Full Accelerator Production of Tritium with helium-3	0.077	0.2	4.0x10 ⁻³	1.7x10 ⁻⁷		0.28	8.6x10 ⁻⁵	5.7x10 ⁻³
Phased Accelerator Production of Tritium	0.077	0.2	2.0x10 ⁻³	8.6x10 ⁻⁸		0.28	8.6x10 ⁻⁵	5.6x10 ⁻³
Tritium Recycling	3.1	7.9	2.0x10 ⁻⁹	0		11	3.3x10 ⁻³	0.22

^a Dose to the population within 50 miles from natural background radiation in year 2030 is equal to 329,800 person-rem.
Source: HNUS 1995a.

TABLE E.2.6.1-4.—Annual Liquid Releases from Normal Operation of No Action at Oak Ridge Reservation (curies)

Isotope	Oak Ridge National Laboratory	Y-12 Plant
H-3	2.5×10^3	0
Co-60	0.17	0
Sr-90	3.2	6.4×10^{-3}
Tc-99	0	9.9×10^{-5}
Cs-137	1.8	0
Ra-226	0	0.032
Ra-228	0	1.4
U-234	0	0.11
U-235	0	6.4×10^{-3}
U-238	0	0.12
Np-237	0	9.8×10^{-4}
Th-228	0	6.3×10^{-3}
Th-230	0	2.8×10^{-3}
Th-232	0	4.6×10^{-4}
Th-234	0	0.015
Pu-238	0	0
Pu-239	0	2.3×10^{-4}

Source: ORR 1993a:8.

TABLE E.2.6.1-5.—Doses and Resulting Health Effect to the Maximally Exposed Individual at Oak Ridge Reservation from Liquid Releases Associated with Normal Operation

Alternative	Dose by Pathway (mrem per year)						Committed Effective Dose Equivalent (mrem per year)	Percent of Background ^a	Estimated Risk of 40-Year Fatal Cancers
	Fish Ingestion	Other Food Ingestion	Drinking Water	Boating	Swimming	Shoreline			
No Action – Advanced Neutron Source Reactor	13	0.022	0.4	4.4x10 ⁻⁵	8.8x10 ⁻⁵	0.027	14	4.4	2.7x10 ⁻⁴
No Action – High Flux Isotope Reactor	13	0.022	0.4	4.4x10 ⁻⁵	8.8x10 ⁻⁵	0.027	14	4.4	2.7x10 ⁻⁴
Heavy Water Reactor	0.13	4.4x10 ⁻³	0.019	1.2x10 ⁻⁵	2.4x10 ⁻⁵	4.8x10 ⁻⁴	0.15	0.05	3.1x10 ⁻⁶
AP600	0.13	0.06	0.2	6.0x10 ⁻⁶	1.2x10 ⁻⁵	9.4x10 ⁻⁴	0.39	0.13	7.8x10 ⁻⁶
Advanced Boiling Water Reactor	0.041	0.03	0.098	2.8x10 ⁻⁶	5.6x10 ⁻⁶	3.3x10 ⁻⁴	0.17	0.055	3.4x10 ⁻⁶
CE System 80+	0.1	0.016	0.051	5.3x10 ⁻⁶	1.1x10 ⁻⁵	8.5x10 ⁻⁴	0.18	0.058	3.5x10 ⁻⁶
Simplified Boiling Water Reactor	0.044	0.039	0.13	2.8x10 ⁻⁶	5.6x10 ⁻⁶	3.4x10 ⁻⁴	0.21	0.07	4.3x10 ⁻⁶

^a Individual annual natural background radiation dose is equal to 306 mrem.
Source: HNUS 1994a.

TABLE E.2.6.1-6.—Doses and Resulting Health Effects to the Population Downstream of Liquid Releases Associated with Normal Operation at Oak Ridge Reservation

Alternative	Dose by Pathway (person-rem in 2030)					Committed Effective Dose Equivalent in 2030 (person-rem)	Percent of Background ^a	Estimated 40-Year Fatal Cancers
	Fish Ingestion	Drinking Water	Boating	Swimming	Shoreline			
No Action – Advanced Neutron Source Reactor	8.8	9.1	2.0x10 ⁻³	1.7x10 ⁻³	0.22	18	5.8x10 ⁻³	0.36
No Action – High Flux Isotope Reactor	8.8	9.1	2.0x10 ⁻³	1.7x10 ⁻³	0.22	18	5.8x10 ⁻³	0.36
Heavy Water Reactor	0.25	0.43	5.6x10 ⁻⁴	4.8x10 ⁻⁴	3.8x10 ⁻³	0.69	2.2x10 ⁻⁴	0.014
AP600	0.31	4.6	2.8x10 ⁻⁴	2.4x10 ⁻⁴	7.6x10 ⁻³	4.9	1.6x10 ⁻³	0.099
Advanced Boiling Water Reactor	0.084	2.3	1.3x10 ⁻⁴	1.1x10 ⁻⁴	2.6x10 ⁻³	2.4	7.7x10 ⁻⁴	0.048
CE System 80+	0.2	1.2	2.4x10 ⁻⁴	2.1x10 ⁻⁴	6.8x10 ⁻³	1.4	4.5x10 ⁻⁴	0.028
Simplified Boiling Water Reactor	0.089	3	1.3x10 ⁻⁴	1.1x10 ⁻⁴	2.7x10 ⁻³	3.1	1.0x10 ⁻³	0.062

^a Dose to the population from natural background radiation in year 2030 is equal to 329,800 person-rem.
Source: HNUS 1995a.

E.2.7 Radiological Impacts at Pantex Plant

This section presents the radiological impacts of the tritium supply technologies and recycling facilities at Pantex. Section E.2.7.1 presents the radiological releases and resulting impacts from facilities associated with No Action. Section E.2.7.2 presents the radiological releases and resulting impacts from the facilities associated with tritium supply technologies and recycling facilities.

For purposes of radiological impact modeling, Pantex was divided into four areas which will release radioactivity in the year 2010. All release points in each area were aggregated into a single release point. Table E.2.7-1 presents the characteristics of each of the release points including location, release height, and minimum distance and annual average dispersion to the site boundary in each of 16 directions. In order to calculate the maximum site boundary dose, the dose from each release point to the maximum receptor associated with each of the other release points has been calculated. For example, the dose resulting from releases from Building 12-44 Cell 1 and the proposed TSS has been determined from the maximum receptor from the Burning Ground. Figure E.2.7-1 illustrates the location of each maximum receptor in relation to each release point. The maximum site boundary dose is then determined by the maximum dose of each of the maximum receptors. Table E.2.7-2 presents the distance, direction, and atmospheric dispersion from each release point to each of the maximum receptors. Annual radiological releases were assumed to remain constant during the 40-year operational period.

Descriptions of population and food stuff distributions centered on each release area are provided in a technical report *Health Risk Data*. The joint frequency distribution used for the dose assessment was based on the meteorological measurements for the year 1989 from the National Weather Service at the 10 meter height and is contained in a technical report (*Health Risk Data*).

Doses given in this section are associated with 1 year of operation because regulatory standards are given as annual limits. The health effects presented are for the 40-year operational period.

E.2.7.1 No Action

Atmospheric Releases. For No Action, two of the areas have radioactive releases into the atmosphere from normal operation. Table E.2.7.1-1 presents the estimated annual atmospheric radioactive releases for No Action.

Liquid Releases. There are no radioactive liquid releases into the offsite environment associated with No Action.

Tables E.2.7.1-2 and E.2.7.1-3 include the radiological impacts to the maximally exposed individual and the offsite population within 50 miles, respectively. The maximally exposed individual would receive an annual dose of 1.3×10^{-3} mrem. An estimated fatal cancer risk of 2.6×10^{-8} would result from 40 years of operation. The population within 50 miles would receive a dose of 5.7×10^{-4} person-rem in the year 2030 (midlife of operation). An estimated 1.1×10^{-5} fatal cancers could result from 40 years of operation.

Worker Doses. Based on measured values during the time period from 1989 to 1992 (*Twenty-Second Annual Report Radiation Exposure for DOE and DOE Contractor Employees - 1989 DOE/EH-0286P*) and subsequent yearly dose reports), the annual average dose to a badged worker at Pantex was calculated to be 15 mrem. It is projected that in the year 2010 and beyond, there would be 2,465 badged workers involved in No Action activities at Pantex (PX 1993a:2). The annual average dose to these workers was assumed to remain at 15 mrem; the annual total dose among all these workers would then equal 37 person-rem. From 40 years of operation, an estimated fatal cancer risk of 2.4×10^{-4} would result to the average worker and 0.59 fatal cancers could result among all workers.

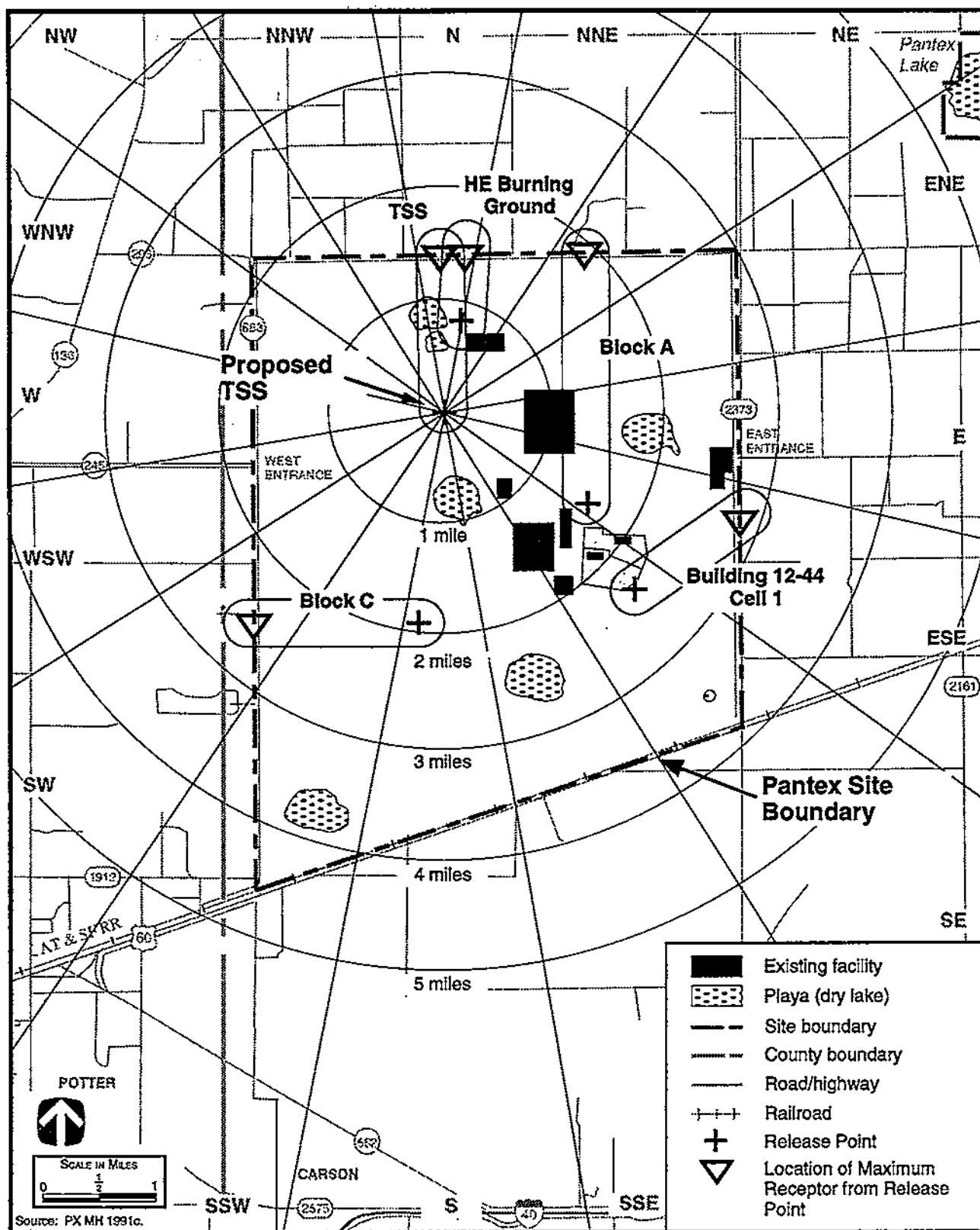
E.2.7.2 Tritium Supply Technologies and Recycling

Total site radiological impacts resulting from tritium supply and recycling can be found by adding the impacts resulting from No Action facilities to those resulting from tritium supply technologies and

recycling facilities. For example, to determine the radiological impact for the addition of the HWR at Pantex, the No Action facilities impacts would be summed with the HWR doses (which includes tritium target extrication) and the tritium recycling doses. Estimated annual atmospheric radioactive releases for the tritium supply technologies and recycling facilities are given in section E.2.3. Tables E.2.7.1-2 and E.2.7.1-3 present the radiological impacts by tritium supply technology and recycling

facility. There are no radioactive liquid releases into the offsite environment associated with any tritium supply and recycling alternative.

The annual doses from total site operations associated with the different tritium supplies ranged from 1.4 to 4.9 mrem to the maximally exposed individual and from 9.2 to 37 person-rem to the 50-mile population in the year 2030. The health effects from 40 years of operation are included in both tables.



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FIGURE E.2.7-1.—Location of Maximum Receptors at Pantex Plant.

TABLE E.2.7-1.—Release Point Characteristics, Direction, Distance and Chi/Q at Pantex Plant Boundary

Release Point	Tritium Supply Site	Burning Ground	Building 12-44, Cell 1	Block C
Latitude	35°19'54.60"	35°20'40.78"	35°18'24.09"	35°18'8.55"
Longitude	-101°35'15.15"	-101°35'4.25"	-101°33'25.59"	-101°33'30.52"
Release Height:	Ground Level	Ground Level	Ground Level	Ground Level

Direction	Accidents				
	50 Percentile 95 Percentile				
	Distance (m)	Chi/Q (sec/m ³)	Chi/Q (s/m ³)	Distance (m)	Chi/Q (sec/m ³)
N.	2,352	5.7x10 ⁻⁷	8.0x10 ⁻⁷	932	2.7x10 ⁻⁶
NNE.	2,397	3.4x10 ⁻⁷	9.3x10 ⁻⁷	958	1.6x10 ⁻⁶
NE.	2,822	2.2x10 ⁻⁷	4.8x10 ⁻⁷	1,119	9.9x10 ⁻⁷
ENE.	4,177	7.2x10 ⁻⁸	2.3x10 ⁻⁷	1,654	3.1x10 ⁻⁷
E.	4,245	8.0x10 ⁻⁸	2.9x10 ⁻⁷	3,983	8.8x10 ⁻⁸
ESE.	4,317	5.3x10 ⁻⁸	5.2x10 ⁻⁷	4,062	5.8x10 ⁻⁸
SE.	5,047	5.5x10 ⁻⁸	3.9x10 ⁻⁷	5,036	5.5x10 ⁻⁸
SSE.	6,165	3.1x10 ⁻⁸	2.4x10 ⁻⁷	6,934	2.6x10 ⁻⁸
S.	6,227	5.7x10 ⁻⁸	1.0x10 ⁻⁷	7,472	4.4x10 ⁻⁸
SSW.	5,121	4.6x10 ⁻⁸	1.7x10 ⁻⁷	5,630	4.0x10 ⁻⁸
SW.	3,348	7.7x10 ⁻⁸	4.0x10 ⁻⁷	3,676	6.7x10 ⁻⁸
WSW.	2,801	1.5x10 ⁻⁷	1.8x10 ⁻⁶	3,087	1.3x10 ⁻⁷
W.	2,724	1.5x10 ⁻⁷	1.2x10 ⁻⁶	2,999	1.3x10 ⁻⁷
WNW.	2,769	1.1x10 ⁻⁷	6.1x10 ⁻⁷	1,742	2.4x10 ⁻⁷
NW.	2,860	1.7x10 ⁻⁷	5.6x10 ⁻⁷	1,151	7.6x10 ⁻⁷
NNW.	2,411	2.3x10 ⁻⁷	7.2x10 ⁻⁷	959	1.1x10 ⁻⁶

Source: HNUS 1995a.

TABLE E.2.7-2.—Direction, Distance, and Meteorological Dispersion to Various Maximum Individual Receptors at the Pantex Site Boundary

	Direction (m)	Distance (m)	Maximum Receptor For:	Atmospheric Dispersion Chi/Q (s/m ³)
Release Point: Tritium Supply Site				
	N.	2372	Burning Ground	5.6x10 ⁻⁷
	ESE.	4585	Bldg. 12-44 Cell 1	4.9x10 ⁻⁸
	N.	2351	Tritium Supply Site	5.7x10 ⁻⁷
	NE.	3158	Block A	4.9x10 ⁻⁸
	SW.	4272	Block C	5.6x10 ⁻⁷
Release Point: Bldg. 12-44 Cell 1				
	NNW.	5713	Burning Ground	6.4x10 ⁻⁸
	NE.	1834	Bldg. 12-44 Cell 1	4.3x10 ⁻⁷
	NNW.	5845	Tritium Supply Site	6.2x10 ⁻⁸
	N.	5213	Block A	4.3x10 ⁻⁷
	W.	5518	Block C	6.4x10 ⁻⁸
Release Point: HE Burning Ground				
	N.	932	Burning Ground	2.7x10 ⁻⁶
	SE.	5066	Bldg. 12-44 Cell 1	5.5x10 ⁻⁸
	NNW.	972	Tritium Supply Site	1.1x10 ⁻⁶
	ENE.	2039	Block A	5.5x10 ⁻⁸
	SW.	5588	Block C	2.7x10 ⁻⁶
Release Point: Block A				
	NNW.	3893	Burning Ground	1.1x10 ⁻⁷
	E.	3893	Bldg. 12-44 Cell 1	9.1x10 ⁻⁸
	NNW.	4332	Tritium Supply Site	9.5x10 ⁻⁸
	N.	3803	Block A	2.7x10 ⁻⁷
	WSW.	5183	Block C	5.9x10 ⁻⁸
Release Point: Block C				
	N.	5664	Burning Ground	1.5x10 ⁻⁷
	ENE.	4896	Bldg. 12-44 Cell 1	5.7x10 ⁻⁸
	N.	5633	Tritium Supply Site	1.5x10 ⁻⁷
	NNE.	6162	Block A	8.3x10 ⁻⁸
	W.	2339	Block C	1.9x10 ⁻⁷

Source: HNUS 1995a.

TABLE E.2.7.1-1.—Estimated Annual Atmospheric Radioactive Releases from Normal Operation of No Action at Pantex Plant (curies)

Isotope	Weapons Assembly/ Disassembly High Explosive		
	Building 12-44 Cell 1	Burning Ground	Plutonium Storage
Helium-3	0.12	0	0
Uranium-238	0	2.1x10 ⁻⁵	0

Source: PX 1993a:2.

TABLE E.2.7.1-2.—Doses and Resulting Health Effect to the Maximally Exposed Individual Resulting from Normal Operation at Pantex Plant

Alternative	Dose by Pathway (mrem per year)					Committed Effective Dose Equivalent (mrem per year)	Percent of Background ^a	Estimated 40-Year Fatal Cancer Risk
	Inhalation	Ingestion	Plume Immersion	Ground Shine				
No Action	1.3×10^{-3}	5.0×10^{-6}	1.2×10^{-12}	9.9×10^{-8}		1.3×10^{-3}	4.2×10^{-4}	2.6×10^{-8}
No Action contribution to tritium supply site maximum receptor	5.0×10^{-4}	2.9×10^{-6}	4.4×10^{-13}	3.8×10^{-8}		5.0×10^{-4}	1.5×10^{-4}	1.0×10^{-8}
Heavy Water Reactor	0.52	1.9	6.8×10^{-3}	2.4×10^{-3}		2.4	0.7	4.8×10^{-5}
Modular High Temperature Gas-Cooled Reactor	0.07	0.94	1.7×10^{-3}	7.9×10^{-4}		1	0.29	2.0×10^{-5}
Advanced Boiling Water Reactor	0.21	3.2	0.095	9.8×10^{-3}		3.5	1	7.0×10^{-5}
CE System 80+	0.21	3.1	7.9×10^{-3}	4.2×10^{-3}		3.2	0.93	6.4×10^{-5}
Simplified Boiling Water Reactor	0.21	3.2	0.024	0.024		3.4	0.99	6.8×10^{-5}
AP600	0.21	3.1	0.022	6.4×10^{-3}		3.3	0.96	6.6×10^{-5}
Full Accelerator Production of Tritium with helium-3	2.4×10^{-3}	0.033	1.8×10^{-4}	3.7×10^{-7}		0.035	0.01	7.0×10^{-7}
Full Accelerator Production of Tritium with spallation-induced lithium conversion	0.049	0.66	1.8×10^{-4}	3.7×10^{-7}		0.71	0.21	1.4×10^{-5}
Phased Accelerator Production of Tritium	2.4×10^{-3}	0.033	8.9×10^{-5}	1.9×10^{-7}		0.035	0.01	7.0×10^{-7}
Tritium Recycling	0.099	1.3	9.4×10^{-11}	0		1.4	0.4	2.8×10^{-5}

^a Individual annual natural background radiation dose is equal to 346 mrem.

Source: HNUS 1995a.

TABLE E.2.7.1-3.—Doses and Resulting Health Effect to the Population Within 50 Miles Resulting from Normal Operation of Pantex Plant

Alternative	Dose by Pathway (person-rem in 2030)					Committed Effective Dose Equivalent in 2030 (person-rem)	Percent of Background ^a	Estimated 40-Year Fatal Cancers
	Inhalation	Ingestion	Plume Immersion	Ground Shine				
No Action	4.5x10 ⁻⁴	1.2x10 ⁻⁴	5.4x10 ⁻¹³	3.6x10 ⁻⁸	5.7x10 ⁻⁴	5.7x10 ⁻⁴	5.7x10 ⁻⁴	1.1x10 ⁻⁵
Heavy Water Reactor	0.92	17	8.5x10 ⁻³	4.3x10 ⁻³	19	19	0.019	0.37
Modular High Temperature Gas-Cooled Reactor	0.12	6.3	2.1x10 ⁻³	1.1x10 ⁻³	6.5	6.5	6.5x10 ⁻³	0.13
Advanced Boiling Water Reactor	0.38	26	0.057	0.016	28	28	0.028	0.55
CE System 80+	0.38	25	0.01	7.5x10 ⁻³	26	26	0.026	0.51
Simplified Boiling Water Reactor	0.39	24	0.017	0.041	25	25	0.025	0.49
AP600	0.38	25	0.033	0.012	26	26	0.026	0.51
Full Accelerator Production of Tritium with helium-3	4.3x10 ⁻³	0.22	2.5x10 ⁻⁴	8.3x10 ⁻⁹	0.23	0.23	2.3x10 ⁻⁴	4.6x10 ⁻³
Full Accelerator Production of Tritium with spallation-induced lithium conversion	0.087	4.4	2.5x10 ⁻⁴	8.3x10 ⁻⁹	4.5	4.5	4.5x10 ⁻³	0.09
Phased Accelerator Production of Tritium	4.3x10 ⁻³	0.22	1.3x10 ⁻⁴	4.2x10 ⁻⁹	0.23	0.23	2.3x10 ⁻⁴	4.6x10 ⁻³
Tritium Recycling	0.17	8.8	1.7x10 ⁻¹⁰	0	9	9	9.0x10 ⁻³	0.18

^a Dose to the population within 50 miles from natural background radiation in 2030 is equal to 99,470 person-rem.
Source: HNUS 1995a.

E.2.8 Radiological Impacts at Savannah River Site

This section presents the radiological impacts of the tritium supply technologies and recycling facilities at SRS. Section E.2.8.1 presents the radiological releases and resulting impacts from facilities associated with No Action. Section E.2.8.2 presents the radiological releases and resulting impacts from the facilities associated with the tritium supply technologies and recycling facilities.

For purposes of radiological impact modeling, SRS was divided into seven areas. All potential release points in each area were aggregated into a single release point. Table E.2.8-1 presents the characteristics of each of the release points including location, release height, minimum distance, and annual average dispersion to the site boundary in each of 16 directions. In order to calculate the maximum site boundary dose, the dose from each release point to the maximum receptor associated with each of the other release points has been calculated. For example, the dose resulting from releases from F-, H-, and S-Areas, the K- and L-Reactors, and the proposed TSS is determined for the maximum receptor from the Savannah River Tech Center Laboratory in A-Area. Figure E.2.8-1 illustrates the location of each maximum receptor in relation to each release point. The maximum site boundary dose is then determined by the maximum dose of each of the maximum receptors. Table E.2.8-2 presents the direction, distance, and atmospheric dispersion from each release point to each of the maximum receptors. Annual radiological releases were assumed to remain constant during the 40-year operational period.

Descriptions of population and food stuffs distributions centered on each release area are provided in the technical report *Health Risk Data*. The joint frequency distribution used for the dose assessment was based on the meteorological measurements for the year 1985 from the meteorological tower at SRS at the 61-meter height and is contained in the technical report *Health Risk Data*.

Doses given in this section are associated with 1 year of operation because regulatory standards are given as annual limits. The health effects presented are for the 40-year operational period.

E.2.8.1 No Action

Atmospheric Releases. For No Action, all of the areas have radioactive releases into the atmosphere from normal operation. Tables E.2.8.1-1 and E.2.8.1-2 present the estimated annual atmospheric radioactive releases. Tables E.2.8.1-3 and E.2.8.1-4 present the radiological impacts to the maximally exposed individual and the offsite population within 50 miles, respectively. The maximally exposed individual would receive an annual dose of 2.8 mrem. An estimated fatal cancer risk of 5.6×10^{-5} would result from 40 years of operation. The population within 50 miles would receive a dose of 250 person-rem in the year 2030 (midlife of operation). An estimated 4.9 fatal cancers could result from 40 years of operation.

Liquid Releases. For No Action, some areas may have radioactive releases to the offsite surface water from normal operation. Table E.2.8.1-5 presents the estimated annual liquid radioactive releases.

Tables E.2.8.1-6 and E.2.8.1-7 present the radiological impacts to the maximally exposed member of the public and the offsite populations using water from the Savannah River downstream of SRS to the Atlantic Ocean. The maximally exposed member of the public would receive an annual dose of 0.077 mrem. An estimated fatal cancer risk of 1.5×10^{-6} would result from 40 years of operation. The population would receive a dose of 0.45 person-rem in the year 2030. An estimated 9.0×10^{-3} fatal cancers could result from 40 years of operation.

Worker Doses. It is projected that the annual average dose among the 14,864 badged workers involved in No Action activities at SRS in the year 2010 and beyond would be 32 mrem and the annual total dose among all these workers would equal 480 person-rem (SRS 1993a:3). From 40 years of operation, an estimated fatal cancer risk of 5.2×10^{-4} would result to the average worker and 7.7 fatal cancers could result from all workers.

E.2.8.2 Tritium Supply Technologies and Recycling

Atmospheric Releases. For the tritium supply technologies and recycling facilities, total site radiological

impacts resulting from tritium supply technologies and recycling facilities can be found by adding the impacts resulting from No Action facilities to those resulting from tritium supply technologies and recycling facilities. The No Action doses include contributions from current tritium extraction and recycle operations. For the population doses, these contributions are 30 person-rem and 180 person-rem, respectively. For the maximally exposed individual, they are 0.35 mrem and 1.2 mrem, respectively.

As an example, to determine the radiological impact for the addition of an HWR at SRS, the No Action facilities doses would be summed with the HWR doses (which includes tritium target extraction) and the tritium recycling doses. Estimated annual atmospheric radioactive releases for the tritium supply and recycling facilities are given in section E.2.3. Tables E.2.8.1-3 and E.2.8.1-4 present the radiological impacts by tritium supply technology and recycling facility.

The annual dose from total site operations associated with the different tritium supplies ranged from 2.5 to

3.9 mrem to the maximally exposed individual and from 220 to 340 person-rem to the 50-mile population in the year 2030. The health effects from 40 years of operation are included in both tables.

Liquid Releases. The HWR and the Large and Small ALWRs technologies would release liquid discharges to the surface water surrounding SRS. The liquid releases for these technologies are presented in section E.2.3. For example, to determine the liquid radiological impact for the addition of the HWR at SRS, the No Action liquid radiological impacts would be summed with the HWR liquid doses. Tables E.2.8.1-5 and E.2.8.1-6 present the liquid radiological impacts for the applicable alternatives.

The annual incremental doses from total site operation associated with the different tritium supplies that would release liquids ranged from 0.086 to 0.19 mrem to the maximally exposed member of the public and from 0.5 to 3.3 person-rem to the downstream population in the year 2030. The health effects from 40 years of operation are included in both tables.

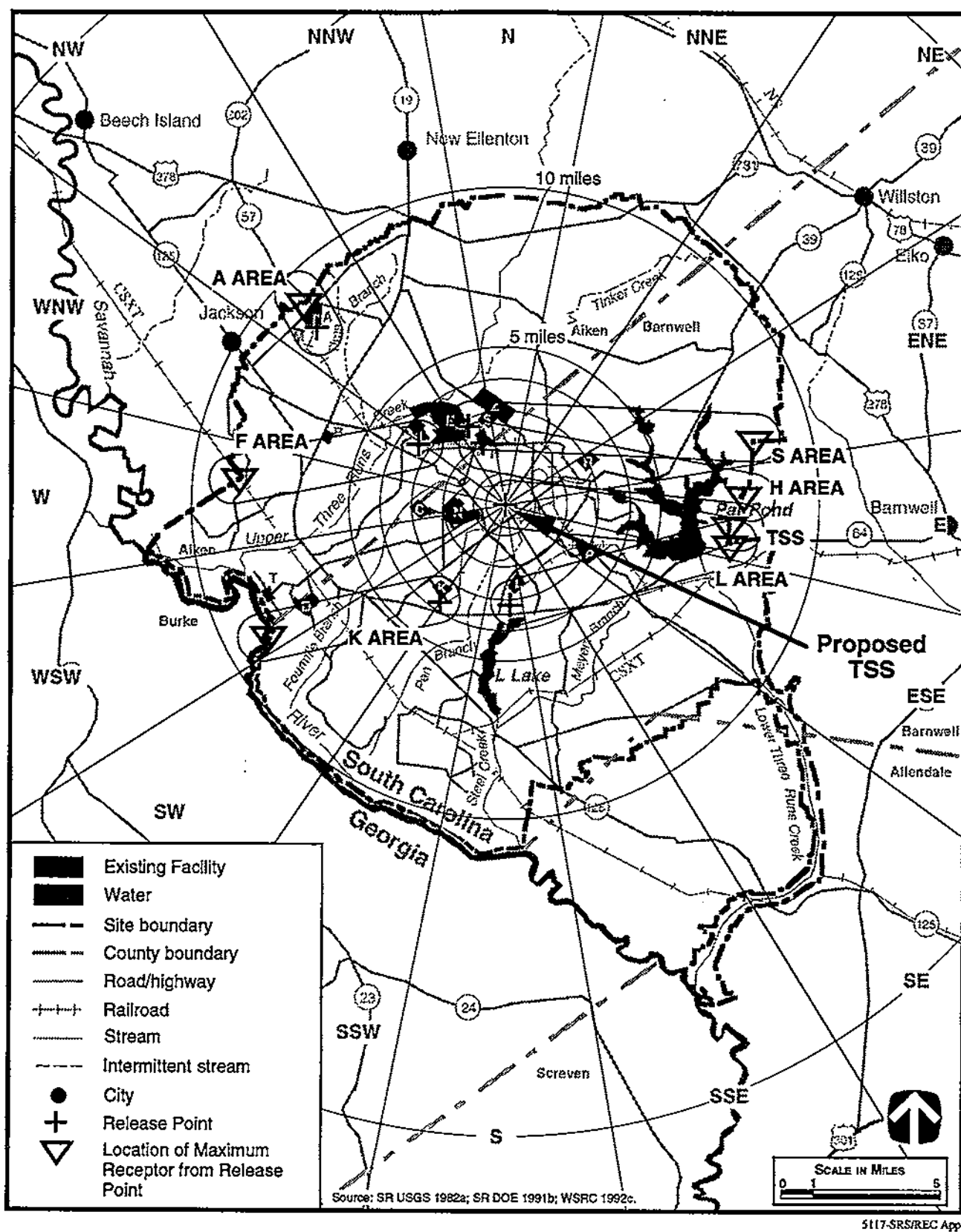


FIGURE E.2.8-1.—Location of Maximum Receptors at Savannah River Site.

TABLE E.2.8-1. Release Point Characteristics, Direction, Distance, and Chi/Q at Savannah River Site Boundary [Page 1 of 2]

Latitude Longitude Release Height:	A-Area		F-Area		H-Area		K-Area	
	33°20'24.36"		33°17'11.40"		33°17'11.04"		33°12'42.12"	
	-81°44'6.72"		-81°40'34.68"		-81°38'25.07"		-81°39'49.31"	
	10.0 meters		10.0 meters		10.0 meters		10.0 meters	
Accident								
50 Percentile 95 Percentile								
Direction	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)
N.	1,920	2.6x10 ⁻⁶	10,895	2.3x10 ⁻⁷	12,280	1.9x10 ⁻⁷	19,112	1.1x10 ⁻⁷
NNE.	3,260	1.5x10 ⁻⁶	12,646	2.2x10 ⁻⁷	12,860	2.2x10 ⁻⁷	21,418	1.1x10 ⁻⁷
NE.	5,447	8.2x10 ⁻⁷	14,762	2.1x10 ⁻⁷	14,889	2.1x10 ⁻⁷	21,727	1.2x10 ⁻⁷
ENE.	12,422	3.0x10 ⁻⁷	18,536	1.7x10 ⁻⁷	15,959	2.1x10 ⁻⁷	15,630	2.2x10 ⁻⁷
E.	21,490	1.6x10 ⁻⁷	17,109	2.2x10 ⁻⁷	14,055	2.8x10 ⁻⁷	15,628	2.5x10 ⁻⁷
ESE.	23,855	9.9x10 ⁻⁸	16,944	1.6x10 ⁻⁷	13,690	2.1x10 ⁻⁷	13,427	2.1x10 ⁻⁷
SE.	27,208	4.8x10 ⁻⁸	19,773	7.3x10 ⁻⁸	17,634	8.6x10 ⁻⁸	11,434	1.5x10 ⁻⁷
SSE.	25,922	3.3x10 ⁻⁸	18,932	5.0x10 ⁻⁸	17,662	5.5x10 ⁻⁸	10,834	1.1x10 ⁻⁷
S.	14,864	7.1x10 ⁻⁸	18,520	5.3x10 ⁻⁸	18,108	5.5x10 ⁻⁸	11,121	1.1x10 ⁻⁷
SSW.	7,327	2.7x10 ⁻⁷	15,478	9.6x10 ⁻⁸	18,479	7.6x10 ⁻⁸	10,683	1.6x10 ⁻⁷
SW.	5,280	6.9x10 ⁻⁷	11,521	2.3x10 ⁻⁷	14,338	1.7x10 ⁻⁷	10,613	2.6x10 ⁻⁷
WSW.	3,434	1.5x10 ⁻⁶	9,639	3.5x10 ⁻⁷	14,207	2.1x10 ⁻⁷	9,147	3.8x10 ⁻⁷
W.	2,588	1.8x10 ⁻⁶	9,421	3.0x10 ⁻⁷	12,768	2.0x10 ⁻⁷	8,856	3.3x10 ⁻⁷
WNW.	1,751	2.5x10 ⁻⁶	9,838	2.2x10 ⁻⁷	12,662	1.5x10 ⁻⁷	12,320	1.6x10 ⁻⁷
NW.	1,575	2.3x10 ⁻⁶	9,459	1.8x10 ⁻⁷	11,893	1.3x10 ⁻⁷	13,277	1.1x10 ⁻⁷
NNW.	1,395	2.7x10 ⁻⁶	9,963	1.7x10 ⁻⁷	11,750	1.4x10 ⁻⁷	17,101	8.3x10 ⁻⁸

TABLE E.2.8-1.—Release Point Characteristics, Direction, Distance, and Chi/Q at Savannah River Site Boundary [Page 2 of 2]

Direction	L-Area		S-Area		Tritium Supply Site	
	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)
	10.0 meters	10.0 meters	10.0 meters	10.0 meters	10.0 meters	10.0 meters
Latitude	33°12'38.52"	33°17'42.72"	33°15'28.80"			
Longitude	-81°37'26.40"	-81°38'35.15"	-81°37'33.96"			
Release Height:	10.0 meters	10.0 meters	10.0 meters	10.0 meters	10.0 meters	10.0 meters
Accident						
50 Percentile 95 Percentile						
	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)	Distance (m)	Chi/Q (sec/m ³)
N.	20,731	9.6x10 ⁻⁸	11,286	2.2x10 ⁻⁷	15,564	1.4x10 ⁻⁷
NNE.	21,141	1.1x10 ⁻⁷	11,984	2.4x10 ⁻⁷	15,856	1.6x10 ⁻⁷
NE.	15,520	1.9x10 ⁻⁷	14,240	2.2x10 ⁻⁷	16,560	1.8x10 ⁻⁷
ENE.	12,052	3.1x10 ⁻⁷	15,663	2.2x10 ⁻⁷	13,279	2.7x10 ⁻⁷
E.	13,327	3.1x10 ⁻⁷	14,623	2.7x10 ⁻⁷	11,822	3.6x10 ⁻⁷
ESE.	11,184	2.7x10 ⁻⁷	14,223	2.0x10 ⁻⁷	11,822	3.6x10 ⁻⁷
SE.	9,886	1.9x10 ⁻⁷	18,443	8.1x10 ⁻⁸	14,551	1.1x10 ⁻⁷
SSE.	9,298	1.3x10 ⁻⁷	18,667	8.1x10 ⁻⁸	14,255	7.4x10 ⁻⁸
S.	9,587	1.3x10 ⁻⁷	19,113	5.1x10 ⁻⁸	14,819	7.2x10 ⁻⁸
SSW.	12,157	1.3x10 ⁻⁷	19,048	7.3x10 ⁻⁸	16,910	8.5x10 ⁻⁸
SW.	12,497	2.1x10 ⁻⁷	14,544	1.7x10 ⁻⁷	15,675	1.5x10 ⁻⁷
WSW.	13,516	2.2x10 ⁻⁷	12,868	2.4x10 ⁻⁷	13,864	2.1x10 ⁻⁷
W.	12,508	2.0x10 ⁻⁷	12,473	2.0x10 ⁻⁷	14,146	1.7x10 ⁻⁷
WNW.	15,662	1.1x10 ⁻⁷	11,487	1.7x10 ⁻⁷	14,384	1.3x10 ⁻⁷
NW.	17,091	8.2x10 ⁻⁸	10,982	1.5x10 ⁻⁷	14,974	9.8x10 ⁻⁸
NNW.	19,321	7.0x10 ⁻⁸	10,741	1.5x10 ⁻⁷	15,132	9.7x10 ⁻⁸

Source: HNUS 1995a.

TABLE E.2.8-2.—Direction, Distance, and Meteorological Dispersion to Various Maximum Individual Receptors at Savannah River Site Boundary. [Page 1 of 2]

	Direction	Distance (m)	Maximum Receptor For:	Atmospheric Dispersion Chi/Q (sec/m ³)
Release Point: A- Area				
	NNW.	1,396	A-Area	2.7x10 ⁻⁶
	SSW.	9,638	F-Area	2.1x10 ⁻⁷
	ESE	24,209	H-Area	9.7x10 ⁻⁸
	S.	16,255	K-Area	6.3x10 ⁻⁸
	ESE.	24,650	L-Area	9.5x10 ⁻⁸
	E.	23,833	S-Area	1.4x10 ⁻⁷
	ESE.	24,175	Tritium Supply Site	9.7x10 ⁻⁸
Release Point: F-Area				
	NW.	9,460	A-Area	1.8x10 ⁻⁷
	WSW.	9,638	F-Area	3.5x10 ⁻⁷
	E.	17,358	H-Area	2.1x10 ⁻⁷
	SW.	12,787	K-Area	2.0x10 ⁻⁷
	ESE.	17,299	L-Area	1.5x10 ⁻⁷
	E.	17,704	S-Area	2.1x10 ⁻⁷
	ESE.	16,980	Tritium Supply Site	1.5x10 ⁻⁷
Release Point: H-Area				
	NW.	11,932	A-Area	1.3x10 ⁻⁷
	W.	12,930	F-Area	1.9x10 ⁻⁷
	E.	14,055	H-Area	2.8x10 ⁻⁷
	SW.	15,055	K-Area	1.6x10 ⁻⁷
	ESE.	14,139	L-Area	2.0x10 ⁻⁷
	E.	14,357	S-Area	2.8x10 ⁻⁷
	ESE.	13,760	Tritium Supply Site	2.1x10 ⁻⁷
Release Point: K Reactor				
	NNW.	17,101	A-Area	8.3x10 ⁻⁸
	WNW.	12,320	F-Area	1.6x10 ⁻⁷
	ENE.	16,962	H-Area	1.9x10 ⁻⁷
	WSW.	9,146	K-Area	3.8x10 ⁻⁷
	E.	15,627	L-Area	2.5x10 ⁻⁷
	ENE.	18,642	S-Area	1.7x10 ⁻⁷
	ENE.	15,803	Tritium Supply Site	2.1x10 ⁻⁷
Release Point: L Reactor				
	NW.	19,081	A-Area	7.1x10 ⁻⁸
	WNW.	15,661	F-Area	1.1x10 ⁻⁷
	ENE.	13,579	H-Area	2.6x10 ⁻⁷
	W.	12,775	K-Area	2.0x10 ⁻⁷
	ENE.	12,051	L-Area	3.1x10 ⁻⁷
	NE.	15,519	S-Area	1.9x10 ⁻⁷
	ENE.	12,302	Tritium Supply Site	3.0x10 ⁻⁷

TABLE E.2.8-2.—Direction, Distance, and Meteorological Dispersion to Various Maximum Individual Receptors at Savannah River Site Boundary [Page 2 of 2]

	Direction	Distance (m)	Maximum Receptor For:	Atmospheric Dispersion Chi/Q (sec/m ³)
Release Point: S-Area				
	NW.	11,159	A-Area	1.5×10^{-7}
	WSW.	12,867	F-Area	2.4×10^{-7}
	ESE.	14,517	H-Area	1.9×10^{-7}
	SW.	15,548	K-Area	1.5×10^{-7}
	ESE.	14,759	L-Area	1.9×10^{-7}
	E.	14,622	S-Area	2.7×10^{-7}
	ESE.	14,328	Tritium Supply Site	1.9×10^{-7}
Release Point: Tritium Supply Site				
	NW.	14,974	A-Area	9.8×10^{-8}
	W.	14,146	F-Area	1.7×10^{-7}
	E.	12,498	H-Area	2.1×10^{-7}
	WSW.	14,285	K-Area	2.1×10^{-7}
	E.	12,001	L-Area	3.5×10^{-7}
	ENE.	13,487	S-Area	2.6×10^{-7}
	E.	11,822	Tritium Supply Site	3.6×10^{-7}

Source: HNUS 1995a.

TABLE E.2.8.1-1.—Annual Atmospheric Radioactive Releases from Normal Operation of No Action at Savannah River Site (curies)

Isotope	SRTC	K-Reactor	L-Reactor	F-Canyon	H-Canyon	RBOF
H-3	0	3.9×10^3	670	0	0	0
C-14	0	0	0	0	0	0
Ar-41	0	25	0	0	0	0
Cr-51	0	0	0	0	0	0
Co-60	0	0	0	0	0	3.6×10^{-7}
Se-79	0	0	0	0	0	0
Sr-89	0	0	0	0	0	0
Sr-90	0	0	0	2.6×10^{-5}	1.1×10^{-4}	0
Y-90	0	0	0	0	0	0
Y-91	0	0	0	0	0	0
Zr-95	0	0	0	0	0	0
Nb-95	0	0	0	0	0	0
Tc-99	0	0	0	0	0	0
Ru-106	0	0	0	0	0	0
Rh-106	0	0	0	0	0	0
Sn-126	0	0	0	0	0	0
Sb-125	0	0	0	0	0	0
Te-125m	0	0	0	0	0	0
Te-127m	0	0	0	0	0	0
Te-127	0	0	0	0	0	0
I-129	0	0	0	0	0	0
I-131	5.7×10^{-5}	1.4×10^{-7}	0	0	2.1×10^{-5}	0
I-133	1.2×10^{-3}	0	0	0	0	0
I-135	0.13	0	0	0	0	0
Xe-135	2.4×10^{-3}	0	0	0	0	0
Cs-134	0	0	0	0	0	0
Cs-135	0	0	0	0	0	0
Cs-137	3.9×10^{-6}	4.1×10^{-7}	2.6×10^{-6}	8.5×10^{-6}	8.7×10^{-5}	1.7×10^{-6}
Ce-144	0	0	0	0	0	0
Pr-144	0	0	0	0	0	0
Pm-147	0	0	0	0	0	0
Sm-151	0	0	0	0	0	0
Eu-152	0	0	0	0	0	0
Eu-154	0	0	0	0	0	0
Eu-155	0	0	0	0	0	0
U-235	0	0	0	7.3×10^{-4}	3.7×10^{-5}	0
Pu-238	0	0	0	4.1×10^{-5}	1.8×10^{-4}	0
Pu-239	0	0	0	1.6×10^{-4}	5.6×10^{-5}	0
Pu-240	0	0	0	0	0	0
Pu-241	0	0	0	0	0	0
Am-241	2.3×10^{-8}	0	0	2.4×10^{-4}	2.4×10^{-5}	0
Cm-244	7.9×10^{-8}	0	0	3.6×10^{-6}	7.5×10^{-6}	0

Note: SRTC - Savannah River Technology Center; RBOF - Receiving Basin for Offsite Fuels.

Source: SRS 1993a:3.

TABLE E.2.8.1-2.—Annual Atmospheric Radioactive Releases from Waste Management Facilities During Normal Operation of No Action at Savannah River Site (curies)

Isotope	Waste Management		Tritium Facilities	DWPF	Consolidated Incineration Facility
	F-Area	H-Area			
H-3	0	2.1×10^{-5}	3.5×10^4	20	1.2×10^{-5}
C-14	0	0	0	0.021	0
Ar-41	0	0	0	0	0
Cr-51	0	0	0	0	0.015
Co-60	0	0	0	6.1×10^{-8}	1.4×10^{-4}
Se-79	0	0	0	8.8×10^{-9}	0
Sr-89	0	0	0	0	6.0×10^{-4}
Sr-90	0	0	0	2.3×10^{-5}	0.022
Y-90	0	0	0	2.4×10^{-5}	7.6×10^{-5}
Y-91	0	0	0	0	4.5×10^{-4}
Zr-95	0	0	0	0	4.7×10^{-4}
Nb-95	0	0	0	0	1.5×10^{-3}
Tc-99	0	0	0	3.8×10^{-7}	0
Ru-106	0	1.8×10^{-6}	0	3.2×10^{-5}	1.8×10^{-4}
Rh-106	0	0	0	0	1.8×10^{-4}
Sn-126	0	0	0	6.9×10^{-8}	0
Sb-125	0	0	0	6.7×10^{-7}	0
Te-125m	0	0	0	1.0×10^{-5}	0
Te-127m	0	0	0	4.5×10^{-9}	0
Te-127	0	0	0	4.4×10^{-9}	0
I-129	0	0	0	8.2×10^{-5}	0
I-131	0	0	0	0	0
I-133	0	0	0	0	0
I-135	0	0	0	0	0
Xe-135	0	0	0	0	0
Cs-134	0	3.7×10^{-8}	0	2.9×10^{-5}	0
Cs-135	0	0	0	9.4×10^{-7}	0
Cs-137	5.0×10^{-6}	2.0×10^{-5}	0	4.1×10^{-3}	2.4×10^{-4}
Ce-144	0	1.2×10^{-7}	0	3.0×10^{-6}	2.3×10^{-4}
Pr-144	0	0	0	3.1×10^{-6}	2.3×10^{-4}
Pm-147	0	0	0	7.6×10^{-6}	9.1×10^{-4}
Sm-151	0	0	0	1.6×10^{-7}	0
Eu-152	0	0	0	1.4×10^{-9}	0
Eu-154	0	0	0	2.3×10^{-7}	0
Eu-155	0	0	0	1.6×10^{-7}	0
U-235	0	0	0	0	0
Pu-238	0	0	0	7.9×10^{-7}	1.4×10^{-4}
Pu-239	0	0	0	7.1×10^{-9}	5.2×10^{-7}
Pu-240	0	0	0	4.8×10^{-9}	0
Pu-241	0	0	0	7.7×10^{-7}	0
Am-241	0	0	0	8.6×10^{-9}	0
Cm-244	0	0	0	2.7×10^{-8}	0

Note: DWPF - Defense Waste Processing Waste Facility.

Source: SRS 1993a:3.

TABLE E.2.8.1-3.—Doses and Resulting Health Effect to Maximally Exposed Individual from Atmospheric Releases Associated with Normal Operation at Savannah River Site

Alternative	Dose by Pathway (mrem per year)					Committed Effective Dose Equivalent (mrem per year)	Percent of Background ^a	Estimated 40-Year Fatal Cancer Risk
	Inhalation	Ingestion	Plume Immersion	Ground Shine				
No Action	0.2	2.6	2.8x10 ⁻⁴	6.9x10 ⁻⁵		2.8	0.89	5.6x10 ⁻⁵
No Action with Tritium Upgrade	0.15	1.8	2.8x10 ⁻⁴	6.9x10 ⁻⁵		2	0.63	4.0x10 ⁻⁵
Heavy Water Reactor	0.059	0.93	2.2x10 ⁻³	1.0x10 ⁻⁴		0.99	0.31	2.0x10 ⁻⁵
Modular High Temperature Gas-Cooled Reactor	0.036	0.5	5.3x10 ⁻⁴	3.3x10 ⁻⁴		0.53	0.17	1.1x10 ⁻⁵
Advanced Boiling Water Reactor	0.076	1.2	0.012	3.8x10 ⁻³		1.3	0.42	2.6x10 ⁻⁵
CE System 80+	0.094	1.4	2.8x10 ⁻³	1.0x10 ⁻⁴		1.5	0.46	2.9x10 ⁻⁵
Simplified Boiling Water Reactor	0.065	1.1	4.0x10 ⁻³	0.012		1.1	0.36	2.2x10 ⁻⁵
AP600	0.034	0.6	9.4x10 ⁻³	1.1x10 ⁻³		0.64	0.2	1.3x10 ⁻⁵
Full Accelerator Production of Tritium with helium-3	1.2x10 ⁻³	0.017	6.2x10 ⁻⁵	6.7x10 ⁻¹²		0.018	5.7x10 ⁻³	3.6x10 ⁻⁷
Full Accelerator Production of Tritium with spallation-induced lithium conversion	0.024	0.33	6.2x10 ⁻⁵	6.7x10 ⁻¹²		0.35	0.11	7.0x10 ⁻⁶
Phased Accelerator Production of Tritium	1.2x10 ⁻³	0.017	3.2x10 ⁻⁵	3.4x10 ⁻¹²		0.018	5.7x10 ⁻³	3.6x10 ⁻⁷
Tritium Recycling	0.14	2	1.4x10 ⁻¹⁰	0		2.1	0.67	4.2x10 ⁻⁵
Tritium Recycling Upgrade	0.088	1.2	7.9x10 ⁻¹¹	0		1.3	0.41	2.6x10 ⁻⁵

^a Individual annual natural background radiation dose is equal to 315 mrem.
Source: HNUUS 1995a.

TABLE E.2.8.1-4.—Doses and Resulting Health Effect to the Population Within 50 Miles of Savannah River Site from Atmospheric Releases Associated with Normal Operation

Alternative	Dose by Pathway (person-rem in 2030)				Committed Effective Dose Equivalent in 2030 (person-rem)	Percent of Background ^a	Estimated 40-Year Fatal Cancers
	Inhalation	Ingestion	Plume Immersion	Ground Shine			
No Action	13	230	6.8x10 ⁻³	8.0x10 ⁻³	250	0.11	4.9
No Action with Recycle Upgrade	10	160	6.8x10 ⁻³	8.0x10 ⁻³	180	0.075	3.5
Heavy Water Reactor	3.3	84	0.051	4.6x10 ⁻³	87	0.037	1.7
Modular High Temperature Gas-Cooled Reactor	2.1	40	0.01	0.013	42	0.018	0.84
Advanced Boiling Water Reactor	4.2	110	0.36	0.16	110	0.048	2.2
CE System 80+	5	120	0.089	4.8x10 ⁻³	120	0.053	2.5
Simplified Boiling Water Reactor	3.5	85	0.13	0.58	89	0.038	1.8
AP600	2	60	0.32	0.056	62	0.027	1.2
Full Accelerator Production of Tritium with helium-3	0.079	1.4	8.9x10 ⁻⁴	4.9x10 ⁻¹¹	1.5	6.4x10 ⁻⁴	0.03
Full Accelerator Production of Tritium with spallation-induced lithium conversion	1.5	28	8.9x10 ⁻⁴	4.9x10 ⁻¹¹	29	0.012	0.58
Phased Accelerator Production of Tritium	0.079	1.4	4.5x10 ⁻⁴	2.5x10 ⁻¹¹	1.5	6.4x10 ⁻⁴	0.03
Tritium Recycling	9	170	8.7x10 ⁻⁹	0	180	0.077	3.6
Tritium Recycling Upgrade	5.6	100	5.3x10 ⁻⁹	0	110	0.047	2.2

^a Dose to the population within 50 miles from natural background radiation in year 2030 is equal to 233,300 person-rem.
Source: HNUS 1995a.

TABLE E.2.8.1-5.—Annual Liquid Radioactive Releases from Normal Operation of No Action at Savannah River Site (curies)

Isotope	Savannah River Site Release	Isotope	Savannah River Site Release
H-3	1.4×10^3	Cs-137	0.079
S-35	3.2×10^{-5}	Pm-147	2.7×10^{-4}
Co-60	4.8×10^{-5}	U-235	1.4×10^{-5}
Sr-90	9.0×10^{-3}	Pu-238	1.3×10^{-5}
Y-91	2.0×10^{-5}	Pu-239	3.5×10^{-4}
Sb-125	7.2×10^{-5}	Am-241	6.9×10^{-7}
Cs-134	2.2×10^{-5}	Cm-244	2.0×10^{-7}

Source: SRS 1993a:3.

TABLE E.2.8.1-6.—Doses and Resulting Health Effect to the Maximally Exposed Member of the Public from Liquid Releases Associated with Normal Operation at Savannah River Site

Alternative	Dose by Pathway (mrem per year)						Committed Effective Dose Equivalent (mrem per year)	Percent of Background ^a	Estimated 40-Year Fatal Cancers
	Fish Ingestion	Other Food Ingestion	Drinking Water	Boating	Swimming	Shoreline			
No Action	0.065	2.6×10^{-3}	8.4×10^{-3}	6.5×10^{-7}	1.3×10^{-6}	1.9×10^{-4}	0.077	0.024	1.5×10^{-6}
Heavy Water Reactor	0.076	1.9×10^{-3}	8.4×10^{-3}	2.3×10^{-6}	4.6×10^{-6}	2.0×10^{-4}	0.086	0.027	1.7×10^{-6}
Advanced Boiling Water Reactor	0.023	0.017	0.057	7.0×10^{-7}	1.4×10^{-6}	1.5×10^{-4}	0.097	0.031	1.9×10^{-6}
CE System 80+	0.057	6.6×10^{-3}	0.023	2.1×10^{-6}	4.3×10^{-6}	3.7×10^{-4}	0.087	0.027	1.7×10^{-6}
Simplified Boiling Water Reactor	0.023	0.017	0.057	7.0×10^{-7}	1.4×10^{-6}	1.5×10^{-4}	0.097	0.031	1.9×10^{-6}
AP600	0.075	0.026	0.086	2.1×10^{-6}	4.2×10^{-6}	4.1×10^{-4}	0.19	0.060	3.8×10^{-6}

^a Individual annual background radiation dose is equal to 315 mrem.

Source: HNUS 1995a.

TABLE E.2.8.1-7.—Doses and Resulting Health Effect to the Population from Liquid Releases Associated with Normal Operation Downstream of Savannah River Site

Facility	Dose by Pathway (person-rem in 2030)					Committed Effective Dose Equivalent in 2030 (person-rem)	Percent of Background ^a	Estimated 40-Year Fatal Cancers
	Fish Ingestion	Drinking Water	Boating	Swimming	Shoreline			
No Action	0.16	0.29	7.1×10^{-6}	2.1×10^{-6}	3.6×10^{-4}	0.45	2.0×10^{-4}	9.0×10^{-3}
Heavy Water Reactor	0.28	0.22	2.6×10^{-5}	7.4×10^{-6}	3.9×10^{-4}	0.5	2.2×10^{-4}	0.01
Advanced Boiling Water Reactor	0.12	2.0	7.6×10^{-6}	2.2×10^{-6}	2.8×10^{-4}	2.1	9.5×10^{-4}	0.042
CE System 80+	0.25	0.75	2.4×10^{-5}	6.8×10^{-6}	7.1×10^{-4}	1.0	4.5×10^{-4}	0.02
Simplified Boiling Water Reactor	0.12	2.0	7.6×10^{-6}	2.2×10^{-6}	2.8×10^{-4}	2.1	9.5×10^{-4}	0.042
AP600	0.29	3.0	2.3×10^{-5}	6.6×10^{-6}	7.7×10^{-4}	3.3	1.5×10^{-3}	0.066

^a Background dose to the population within 50 miles plus the people who use the Savannah River for drinking water at the Port Wentworth and Beaufort-Jasper (person-rem): 260,000 person-rem in year 2030.
Source: HNUS 1995a.

E.3 HAZARDOUS CHEMICAL IMPACTS TO HUMAN HEALTH

E.3.1 Background

There are two types of adverse health effects normally assessed for hazardous chemical exposure. These are carcinogenic and noncarcinogenic effects. For this reason, two kinds of tables were developed (i.e., a table for chemical toxicity profiles (E.3.2-1) and a table of exposure limits (E.3.3-1)). Table E.3.2-1 characterizes each chemical (either found at the site or associated with tritium supply and recycling) qualitatively so that the risk assessor can determine how exposure might occur (e.g., route of exposure), what effect might occur (e.g., central nervous system dysfunction), and whether the chemical might possess other properties that might affect its bioavailability in a given matrix (e.g., air, water, or soil). Table E.3.3-1 provides the risk assessor with the necessary information to calculate the risk or expected adverse effects that would be expected when an individual is exposed to a hazardous chemical for a long term at low levels (chronic exposure) or to higher concentrations for a short term (acute) exposure. Where a dose effect calculation is required (mg/kg/day), the Reference Dose is applicable and where an inhaled concentration effect is required, the Reference Concentration (mg/m³) is applicable for chronic exposures. The Permissible Exposure Limit, Threshold Limit Value, Short Term Exposure Limit, and Reference Exposure Limit values regulate worker exposures over short-term (e.g., 15-min to 8-hour) exposures that are allowed for these time intervals without adverse acute effects.

It was assumed that under normal operation conditions, members of the public would only receive chronic exposures at low levels from the air emissions from a centrally located source term at each site; because the chemicals are not released into water or soil, that exposure is entirely from inhalation. It was further assumed that the maximally exposed member of the public would be at the site boundary and this assumption was used for all public exposure calculations. For worker exposures to hazardous chemicals, it was assumed that individuals were exposed only to low air emission concentrations during an 8-hour day for a 40-hour week at a point

100 meters from a centrally located source term, since precise placement of source terms onsite cannot be made. Further, it cannot be determined where various workers would be relative to the emission sources.

For every site involved in the analyses, Hazard Indexes (HI) were calculated for all alternative actions relevant to the site. The concentrations of hazardous chemicals identified with each option have been developed by modeling each chemical concentration and individually comparing these concentrations to the Reference Concentration (unique to each chemical) to yield Hazard Quotients (HQ) and the HQs summed to yield the HIs for public exposure. For worker exposures, the concentrations are compared to the Permissible Exposure Limit (unique to each chemical) to yield HQs that are summed to yield HIs. The slope factors for all carcinogens are multiplied by the inhaled dose to determine the cancer risk. Table E.3.3-1 has all slope factors, Reference Concentrations, Reference Dose values, and Permissible Exposure Limits that were used in deriving HIs and cancer risks.

E.3.2 Chemical Toxicity Profiles

Table E.3.2-1 provides the reader with pertinent facts about each chemical that will be included in the risk assessment. This includes the Chemical Abstracts Service number, which aids in a search for information available on any specific chemical and ensures a positive identity regardless of which name or synonym is used. It also contains physical information (i.e., solubility, vapor pressure, and flammability) as well as presenting incompatibility data that is useful in determining whether a hazard might exist and the nature of the hazard. The route of exposure, target organs, and carcinogenicity provide an abbreviated summary on how individuals may get exposed, what body functions could be affected, and whether chronic exposure could lead to cancer in an exposed population. Table E.3.2-1 presents information described above for the hazardous chemicals analyzed in this PEIS.

E.3.3 Regulated Exposure Limits

Hazardous chemicals are regulated by various agencies to provide protection to the public (EPA)

and workers (Occupational Safety and Health Administration (OSHA)), while others and National

Institute for Occupational Safety and Health (American Conference of Governmental Industrial Hygienists) provide guidelines. The Reference Dose and Reference Concentration set by EPA represent exposure limits for long-term (chronic) exposure at low doses and concentrations, respectively, that can be considered safe from adverse noncancer effects. The Permissible Exposure Limit represents levels set by OSHA that are considered safe for 8-hour exposures so as not to cause noncancer adverse effects. The slope factor for each toxic chemical can be used to convert the daily intake averaged over a lifetime of exposure to the incremental risk of an

individual developing cancer. Table E.3.3-1, presents the information on exposure limits that was used to develop HQs for individual hazardous chemicals, the HIs for each option at each site, and the slope factors used to calculate cancer risk for each chemical.

E.3.4 Hazardous Chemical Risk/Effects Calculations

Tables E.3.4-1 through E.3.4-36 present the calculations of HIs and cancer risks for each option for public exposure and workers at all 5 sites. The table numbers correspond exactly to the summary tables appearing in the text, with the risks for all options appearing in the summary table.

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 1 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
Acetic acid	64-19-7	Miscible ^a	11 mm ^a	Class II	Strong oxidizers (esp. chromic acid, sodium peroxide and nitric acid), and strong caustics	inh	Respiratory system, skin, eyes, teeth	f
Acetone	67-64-1	Miscible ^a	180 mm ^a	Class IB	Oxidizers, acids	inh, ing, con	Respiratory system, skin	f
Acetonitrile	75-05-8	Miscible ^a	73 mm ^a	Class IB	Strong oxidizers	inh, abs, ing, con	Kidneys, liver, cardiovascular system, CNS, lungs, skin, eyes	e
Acetylene	74-86-2	Quite ^{k,l} soluble in water (1 vol./1 vol.)	40 atm ¹	Flammable ¹	Brass and copper, salts, oxidants, and silver	inh ¹	Lungs (not serious)	f
Acrolein	107-02-8	40% ^a	210 mm ^a	Class IB	Oxidizers, acids, alkalis, ammonia, amines	inh, ing, con	Heart, eyes, skin, respiratory system	EPA Group C: Possible human carcinogen ^g
Acrylonitrile	107-13-1	7% ^a	83 mm ^a	Class IB	Strong oxidizers, acids, and alkalis, bromine amines	inh, ing, abs, con	CVS, liver, kidneys, CNS, skin, brain tumor, lung, and bowel cancer	EPA Group B1: Probable human carcinogen; limited evidence in human studies ^g
Aliphatic alcohol (n-butyl alcohol)	71-36-3	9% ^a	6mm ^a	Class IC ^a	Strong oxidizers ^a	inh, abs ^a , ing, con	Eyes, skin ^a , respiratory system	f
Aliphatic hydrocarbons (e.g., cyclohexane)	107-13-1	Insoluble	98mm ^a (77 °F)	Class IA ^a	Oxidizers ^a	inh, ing, con	Eyes, respiratory system, skin, CNS	f

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 2 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
Ammonia	7664-41-7	34% in water at 68 °F ^a	>1 atm ^a	Combustible gas, but difficult to burn	Strong oxidizers, acids, halogens, salts of silver and zinc	inh, ing, con	Respiratory system, eyes	
Antimony	7440-36-0	Insoluble	Approx. ^a 0 mm	Noncombustible solid in bulk form, but a moderate explosion hazard in the form of dust when exposed to flame	Strong oxidizers acids ^a , halogenated acids	inh, con	Respiratory system, CVS, skin, eyes	EPA Group A based on radionuclide carcinogenicity
Aromatic petroleum distillate (benzo[a]pyrene)	50-32-8	Insoluble ¹ in water	q	q	e	inh, ing ¹	Respiratory system, ¹ skin	EPA Group B ₂ ; Probable human carcinogen
Aromatic hydrocarbons								
benzo (a) pyrene	50-32-8	Insoluble	e	e	e	ing, inh ¹	Skin, respiratory, liver, intestine, colon ¹	EPA Group B ₂
chrysene	218-01-9	Insoluble	e	e	e	ing, inh ¹	intestine, colon ¹	EPA Group B ₂
pyrene	129-00-0	Insoluble	e	e	e	inh, ing ¹	Kidney ¹	EPA Group D
Benzene	71-43-2	0.07% ^a	75 mm ^a	Class IB	Strong oxidizers, many fluorides and perchlorates, nitric acid	inh, abs, ing, con	Blood, CNS, skin, bone marrow, eyes, respiratory system	EPA Group A: Human carcinogen ^g
Bromoform	75-25-2	0.1% ^a	5mm ^a	Noncombustible	Lithium, sodium potassium, calcium, aluminum, zinc, magnesium, strong caustics, acetone	inh, abs, ing	Skin, liver, kidneys, respiratory system, CNS	EPA Group B ₂ : Probable human carcinogen; sufficient evidence from animal studies, inadequate evidence or no data from human studies ^g

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 3 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
2-Butoxyethanol	111-76-2	Miscible ^a	0.8 mm ^a	Class IIIA ^a	Strong Oxidizers; and strong caustics ^a	inh, abs ^a , ing, con	Liver, kidney ^a , lymphoid system, skin, blood, eyes, respiratory system	f
n-Butyl acetate	123-86-4	1.0% ^a	15 mm ^a (77 °F)	Class IC	Nitrates; strong oxidizers, alkalis, acids	inh, ing, con	Eyes, skin, respiratory system	f
n-Butyl alcohol	71-36-3	9.0% ^a	6 mm ^a	Class IC	Strong oxidizers ^a	inh, abs, ing, con	Skin, eyes, respiratory system ^a	f
Cadmium	7440-43-9	Insoluble ^a	Approx 0 mm ^a	Noncombustible solid in bulk form, but will burn in powder form	Strong oxidizers; elemental sulfur, selenium, and tellurium	inh, ing	Respiratory system, kidneys, prostate, blood	EPA Group B1: Probably human carcinogen; limited evidence in human studies ^g
Cadmium oxide	1306-19-0	Insoluble ^a	Approx 0 mm ^a	Noncombustible		inh	Respiratory system, kidneys, blood	f
Carbon tetrachloride	56-23-5	0.05% ^a	91 mm ^a	Noncombustible	Chemically-active metals such as sodium, potassium and magnesium; fluorine; aluminum; Note: forms highly toxic phosgene gas when exposed to flames or welding arcs	inh, abs, ing, con	CNS, eyes, lungs, liver, kidneys, skin	EPA Group B2: Sufficient evidence in animals, no data for humans
Chlorine	7782-50-5	0.7% ^a	>1 atm ^a	Noncombustible gas, but a strong oxidizer	Reacts explosively or forms explosive compounds with many common substances such as acetylene, ether, ammonia	inh, con	Respiratory system	f

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 4 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
Chlorobenzene	108-90-7	0.05% ^a	12 mm (77 °F) ^a	Class IC	Strong oxidizers	inh, ing, con	Respiratory system, eyes, skin, CNS, liver	EPA Group D: Not classified as to human carcinogenicity ^g
Chlorodifluoromethane (Freon 22)	75-45-6	e	e	Nonflammable ¹ , combustible	e	inh ^m	Respiratory ^j system, CNS, liver, kidney, spleen	EPA Group C: ⁱ Possible human carcinogen
Chloroform	67-66-3	0.5% (77 °F) ^a	160 mm ^a	Noncombustible	Strong caustics, chemically active metals (aluminum or magnesium powder, sodium and potassium), strong oxidizers	inh, ing, con	Liver, kidneys, heart, eyes, skin	EPA Group B2: Probable human carcinogen; sufficient evidence from animal studies, inadequate evidence or no data from human studies ^g
Cleaning solvent (butyl lactate)	138-22-7	Slightly soluble in water	0.4 tors (20 °C)	Autoignition at 382.2 °C	e	inh	Respiratory system	f
Cyanogen	460-19-5	NA	1.8mm ¹	Flammable ¹ Lower explosive limit = 6.6% Upper limit = 32%	e	inh, con ¹	Respiratory ¹ system, eyes	f
Cyclohexane	110-82-7	Insoluble ^a	98 mm (77 °F) ^a	Class IA	Oxidizers	inh, ing, con	Eyes, respiratory system, skin, CNS	f
Diacetone alcohol	123-42-2	Miscible ^a	1mm ^a	Class II ^a	e	inh, abs ^a , ing	Liver, respiratory ^a system, CNS depression, eyes	f
Dibutyl phthalate	84-74-2	0.5% (77 °F) ^a	<0.01 mm ^a	Class IIIB	Nitrates; strong oxidizers, alkalis and acids; liquid chlorine	inh, ing, con	Respiratory system, GI tract	EPA Group D: Not classified as to human carcinogenicity ^g

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 5 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
1,3-Dichloropropene	542-75-6	e	28 tors (20 °C)	28.3 to 3.5 °C Flashpoint explosive limits: 5 to 145% in air	e	inh, con	Eyes, lung, kidney, liver	EPA Group B2: Probable human carcinogen; sufficient evidence from animal studies, inadequate evidence or no data from human studies ^g
Diethylene glycol ethyl ether	111-90-0	NA	4.62mm ^l	Flash Pt. ^l 201 °F	e	ing, abs, ^l con	Skin, eyes ^l	f
Dimethylformamide	68-12-2	Miscible ^a	4 mm ^a (77 °F)	Class IIIA	Carbon tetrachloride, other halogenated compounds when in contact with iron; strong oxidizers; alkyl aluminum; inorganic nitrates	inh, abs, ing, con	Liver, kidneys, CNS, skin	f
Diethyl phthalate	117-81-7	Insoluble ^a	>0.01 mm ^a	Class IIIB	Nitrates; strong oxidizers, acids and alkalis	inh, con, ing	Eyes, upper respiratory system, GI tract	EPA Group B2: Sufficient evidence in animals, no data for humans
2,4-Dinitrotoluene	121-14-2	Insoluble ^a	1.0 mm	Combustible solid, but difficult to ignite	Strong oxidizers, caustics, metals such as tin and zinc	inh, abs, ing, con	Blood, liver, CVS	EPA Group B2: (For mixture) ^g
Epoxy solvent (e.g., toluene)	108-88-3	0.05% ^a at 61 °F	20mm ^a at 65 °F	Class IB ^a	Strong oxidizers	inh, abs, ^a ing, con	CNS, liver, ^a kidneys, skin	f
Ethyl acetate	141-78-6	10% (77 °F) ^a	74 mm ^a	Class IB	Nitrates; strong oxidizers, alkalis and acids	inh, ing, con	Eye, skin, respiratory system	f

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 6 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
Ethyl benzene	100-41-4	0.01% ^a	10 mm (79 °F) ^a	Class IB	Strong oxidizers	inh, ing, con	Eyes, upper respiratory system, skin, CNS	EPA Group D: Not classifiable as to human carcinogenicity ^g
Ethanol	64-17-5	Miscible with water and most organic solvents	43 tors (20 °C)	Class IA		inh, ing	Liver, kidney	Group 1., IARC ^r
Ethylene oxide	75-21-8	Miscible ^a	>1 atm ^a	Class IA	Strong acids, alkalis and oxidizers; chlorides of iron, aluminum and tin; oxides of iron and aluminum	inh, ing, con	Eyes, blood, respiratory system, liver, CNS, kidneys	IARC Group 2A: Suspect human carcinogens, inadequate evidence in humans, adequate evidence in animals (EPA Group B2) ^{l,r}
Formaldehyde	50-00-1	Miscible ^a	>1 atm/1 mm ^a	Class IIIB	Strong oxidizers, alkalis and acids; phenols; urea; pure formaldehyde has a tendency to polymerize	inh, ing, con	Respiratory system, eyes, skin	EPA Group B1: Sufficient evidence in animals, limited evidence in humans ^g
Formic acid	64-18-6	Miscible ^a	35 mm ^a	Class IIIA	Strong oxidizers, strong caustics, concentrated sulfuric acid	inh, ing, con	Respiratory system, skin, kidneys, liver, eyes	
Freon 22 (chloro-difluoromethane)	75-45-6	e	e	Nonflammable ^l	e	inh ^m	Respiratory, CNS, liver, kidney, spleen ^j	Human Evidence Inadequate, Animal evidence limited ⁱ

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 7 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
Freon 12 (dichloro- difluoromethane)	75-71-8	0.03% (77 °F) ^a	>1 atm ^a	Nonflammable gas	Chemically active metals (i.e., sodium, potassium, calcium, powdered aluminum, zinc and magnesium) ^a	inh, con	Cardiovascular system, peripheral nervous system	f
Freon 114 (dichloro- tetrafluoroethane)	76-14-2	0.01%	>1 atm ^a	Nonflammable gas	Chemically active metals (i.e., sodium, potassium, calcium, powdered aluminum, zinc and magnesium; acids; acid fumes	inh, ing, con	Respiratory system, cardiovascular system	f
Freon 11 (trichloro- fluoromethane)	75-69-4	0.1010 (77 °F) ^a	690 mm ^a	e	Sodium, potassium, aluminum, calcium, lithium, barium	inh, ing, con	CVS, skin	f
Freon 113 (trichloro- trifluoroethane)	76-13-1	0.02% ^a (77 °F)	285 mm ^a	Flammable	Aluminum, barium, lithium, samarium, sodium, potassium alloy, titanium	inh, ing, con	CNS, skin	f
Freon TF (trichloro- trifluoromethane)	75-69-4	0.1% ^a at 77 °F	690mm ^a	N/A ^a	Aluminum, barium, lithium, samarium, sodium, potassium alloy, titanium	inh, ing, con	CNS, skin ^a	f
Heptane	142-82-5	0.005% (60 °F) ^a	40 mm (72 °F) ^a	Class IB	Strong oxidizers	inh, ing, con	Skin, respiratory system, peripheral nervous system	Class D
Hexane	110-54-3	0.002% ^a	150 mm (77 °F) ^a	Class IB	Strong oxidizers	inh, ing, con	Skin, eyes, respiratory system, peripheral nervous system ^{a, s}	EPA Group D: Not classifiable as to human carcinogenicity ^g

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 8 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
Hydrocarbons (n-heptane)	142-82-5	.005% ^a at 60° F	40mm ^a at 72° F	Class IB ^a	Strong oxidizers	inh, ing ^a , con	Skin, respiratory ^a system, peripheral nervous system	EPA Group D: Not classifiable as to human carcinogenicity ^f
Hydrochloric acid	7647-01-0	67% (86 °F) ^a	>1 atm ^a	Nonflammable gas	Metals, hydroxides, amines, alkalis; corrosive to most metals	inh, ing, con	Respiratory system, skin, eyes	
Hydrofluoric acid	7664-39-3	Miscible ^a	>1 atm ^a	Nonflammable gas	Metals, water or steam; corrosive to metals	inh, abs, ing, con	Eyes, respiratory system, skin	^f
Hydrogen cyanide	74-90-8	Miscible ^a	630mm ^a	Class IA ^a	Many (amines, oxidizers, acids, water, caustics, etc.)	inh, abs ^a , ing, con	CNS ^a , cardiovascular, liver, kidneys	^f
Hydrogen sulfide	7783-06-4	0.4% ^a	>1 atm ^a	Flammable gas	Strong oxidizers, strong nitric acid, metals	inh, ing, con	Respiratory system, eyes	^f
Isobutane (2-methyl propane)	75-28-5	NA	2.01mm ^p	Lower ^p flammability limit = 1.8% Upper limit = 48%	^e	inh ^a	Respiratory ^p system	^f
Isobutyl acetate	110-19-0	0.6% ^a at 77° F	13mm ^a	Class IB ^a	Nitrates, strong oxidizers, alkalis, and acids	inh	Skin, eyes ^a , respiratory system	^f
Isopropyl alcohol	67-63-0	Miscible	33 mm ^a	Class IB	Strong oxidizers, acetaldehyde, chlorine, ethylene oxide, acids, isocyanates	inh, ing, con	Eyes, respiratory system, skin	^f

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 9 of 13]

Compound	Chemical Abstracts Service No.	Solubility ^a	Vapor Pressure ^{**}	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
Manganese	7439-96-5	Insoluble ^a	Approx 0 mm ^a	Combustible solid	Oxidizers	inh, ing	Respiratory system, CNS, blood, kidneys	EPA Group D: Not classifiable as to human carcinogenicity ^g
Mercury (vapor)	7439-97-6	Insoluble ^a	0.0012 mm	Noncombustible liquid	Acetylene, ammonia, chlorine dioxide, azides, calcium, sodium carbide, lithium, rubidium, copper	inh, abs, con	Skin, respiratory system, CNS, kidneys, eyes	f
Methane	74-828	NA	NA	Flammable gas ^k	NA	inh	Lungs	f
Methanol	67-56-1	Miscible ^a	92 mm ^a	Class IB	Strong oxidizers	inh, abs, ing, con	Eyes, skin, CNS, GI tract	f
Methyl bromide	74-83-9	2% ^a	>1 atm ^a	Flammable gas but only in the presence of a high energy ignition source	Aluminum, magnesium, strong oxidizers	inh, abs, ing, con	CNS, respiratory system, skin, eyes	f
Methylene chloride	75-09-2	2% ^a	350 mm ^a	Combustible liquid	Strong oxidizers; caustics; chemically-active metals such as aluminum, magnesium, powders, etc.	inh, ing, con	Skin, CVS, eyes, CNS	EPA Group B2: Sufficient evidence in animals, limited evidence in humans ^g
Methyl ethyl ketone (2-butanone)	78-93-3	28% ^a	71 mm ^a	Class IB	Strong oxidizers, amines, ammonia, inorganic acids, caustics, copper, isocyanates, pyridines	inh, ing, con	CNS, lungs	EPA Group D: Not classifiable as to human carcinogenicity ⁿ

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 10 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
Methyl isobutyl ketone	108-10-1	2% ^a	16 mm ^a	Class IB	Strong oxidizers, potassium tertbutoxide	inh, ing, con	Respiratory system, eyes, skin, CNS	e
Methyl-tert-butyl-ether (2-methoxy-2-methyl-propane)	1634-04-4	4% ^k	245mm ^k	Ignition at 224 °C ^k	Unstable in acid solutions ^k	inh ^k	e	EPA Group D: Not classifiable as to human carcinogenicity ^g
Naphtha	8030-30-6	Insoluble ^a	<5 atm ^a	Class II	Strong oxidizers	inh, ing, con	Respiratory system, eyes, skin	e
Naphthalene	91-20-3	0.003% ^a	0.08 mm ^a	Combustible solid, but will take effort to ignite	Strong oxidizers, chronic anhydride	inh, abs, ing, con	Eyes, blood, liver, kidneys, skin, RBC, CNS	EPA Group D: Not classifiable as to human carcinogenicity ^g
Nickel (refinery dust)	7440-02-0	Insoluble ^a	Approx 0 mm ^a	Noncombustible solid in bulk form	Strong acids, sulfur, selenium, wood and other combustibles, nickel nitrate	inh, ing, con	Lungs, paranasal sinus, CNS	Nickel refinery dust—EPA Group A: Human carcinogen ^g
Nitric acid	7697-37-2	Miscible ^a	48 mm ^a	Noncombustible liquid, but increases flammability of combustible materials	Combustible materials; metallic powders; hydrogen sulfide, carbides; alcohols	inh, ing, con	Eyes, respiratory system, skin, teeth	f
Nitrocellulose (cellulose tetranitrate)	9004-70-4	NA	NA	Highly flammable ^k	NA	NA	NA	f
Perfluoroalkylether (isoflurane)	26675-46-7	NA	NA	NA	e	inh ^l	Respiratory system, CNS	f
Perfluoro compounds (e.g., tetra CFCs)	76-14-2	0.01% ^a	>1 Atm ^a	Nonflammable ^a	Chemically active metals	inh, ing ^a , con	Respiratory ^a system, cardiovascular	f

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 11 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
Phenol	108-95-2	9% (77 °F) ^a	0.4 mm ^a	Combustible solid	Strong oxidizers, calcium hypochlorite, aluminum chloride, acids	inh, abs, ing, con	Liver, kidneys, skin	EPA Group D: Not classifiable as to human carcinogenicity ^g
Phosphoric acid	7664-38-2	Miscible ^a	0.03 mm ^a	Noncombustible liquid	Strong caustics, most metals	inh, ing, con	Respiratory system, eyes, skin	f
Propane	74-98-6	0.01% ^a	>1 Atm ^a	Lower limit 2% ^p Upper limit 52%	e	inh, con ^a	CNS ^a	f
Propyl glycol methyl ether (propylene glycol monomethyl ether)	107-98-2	NA	NA	NA	e	ing, con, inn	Skin ^l	f
Propylene dichloride	78-87-5	0.3% ^a	40 mm ^a	Class IB	Strong oxidizers, strong acids	inh, con, ing	Skin, eyes, respiratory system, liver, kidneys	EPA Group C: Possible human carcinogen ^f
Resins and formers (toluene-2,4-diisocyanate)	584-84-9	Insoluble ^a	0.01mm ^a at 77° F	Class IIIB ^a	Many (strong oxidizers, water, acids, bases, etc.)	inh, ing ^a , con	Respiratory ^a system, skin	f
Sodium hydroxide	1310-73-2	111% ^a	Approx 0 mm ^a	Noncombustible solid, but when in contact with water may generate enough heat to ignite combustible materials	Water, acids, flammable liquids, organic halo-gens, metals (aluminum, tin, and zinc), nitromethane	inh, ing, con	Eyes, respiratory system, skin	f

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 12 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
Sulfuric acid	7664-93-9	Miscible ^a	1 mm (295 °F) ^a	Noncombustible liquid, but can ignite finely divided combustible metals	Organic materials, chlorates, carbides, fulminates, water, powdered metals; corrosive to metals	inh, ing, con	Respiratory system, eyes, skin, teeth	f
Tetrachloroethane (1,1,2,2)	79-34-5	0.3% ^a	9 mm (86 °F) ^a	Noncombustible liquid ^k	Chemically-active metals ^a , strong caustics, fuming of sulfuric acid	inh, abs, ing, con	liver, kidneys, CNS	EPA Group C: Possible human carcinogen ^e
Tetrachloroethylene	127-18-4	0.02% @ 77°F	9mm 86°F	Noncombustible liquid	Strong oxidizers, chemically active metals, caustic soda, sodium hydroxide ^e	ing, inh, con	Liver, kidneys, CNS, eyes, upper respiratory system	EPA Group B2
Tetrahydrofuran	109-99-9	Miscible ^a	132mm ^a	Class IB ^a		inh, ing ^a , con	Eyes, skin, CNS ^a , respiratory system	f
Toluene	108-88-3	0.05% ^a (61°F)	20 mm ^a (65 °F)	Class IB	Strong oxidizers	inh, abs, ing, con	CNS, liver, kidneys, skin	f
Trichloroethane (1,1,1)	71-55-6	Insoluble ^k	^e	Nonflammable liquid ^k	^e	inh ^k	CNS, eyes, mucus membrane ^k	f
Trichloroethylene	79-01-6	0.1% (77 °F) ^a	58 mm	Class IC	Strong caustics and alkalis; chemically-active metals such as barium, lithium, sodium, magnesium, titanium, and beryllium	inh, ing, con	Respiratory system, heart, liver, kidneys, CNS, skin	EPA Group B: Sufficient evidence in animals, inadequate evidence in humans ⁿ
Uranium	7440-61-1	Insoluble ^a	Approx 0 mm ^a	Combustible solid, esp. turnings and powder	Carbon dioxide, carbon tetra-chloride, nitric acid, fluorine	inh, con, ing	Skin, bone marrow, lymphatics	EPA Group A: Human Carcinogen ⁿ

TABLE E.3.2-1.—Chemical Toxicity Profiles [Page 13 of 13]

Compound	Chemical Abstracts Service No.	Solubility*	Vapor Pressure**	Flammability ^{a,b}	Incompatibilities ^a	Route of Exposure ^{a,c}	Target Organs ^a	Carcinogenicity ^d
Vinyl acetate	108-05-4	1g/50ml water ^k at 20°C	100 ⁿ	Flammable liquid ^m	Oxygen ⁿ , hydrogen peroxide	inh, con ^m	Skin, eye ^m	EPA Group D: Inadequate evidence in animals ^o
Vinyl chloride	75-01-4	0.1% (77 °F) ^a	>1 atm ^a	Flammable gas	Copper, oxidizers, aluminum, peroxides, iron, steel	inh	Liver, CNS, blood, respiratory system, lymphatic system	EPA Group A: Human Carcinogen ^o
Xylene (o-, m-, p-isomers)	1330-20-7	Insoluble ^a	7/9/9 mm ^a	IB (o-) IC (m-, p-)	Strong oxidizers	inh, abs, ing, con	CNS, eyes, GI tract, blood, liver, kidneys, skin ^a	f

^a NIOSH 1990a; ORNL 1993b.
^b Flammable liquids are classified by OSHA (29 CFR 1910.106) as follows:
Class IA-Fl.P below 73 °F and BP below 100 °F;
Class IB-Fl.P below 73 °F and BP at or above 100 °F;
Class IC-Fl.P at or above 73 °F and below 100 °F;
Class II-Fl.P at or above 100 °F and below 140 °F;
Class IIIA-Fl.P at or above 140 °F and below 200 °F;
Class IIIB-Fl.P at or above 200 °F.
^c Routes of exposure abbreviated as follows:
inh-inhalation;
abs-skin absorption;
ing-ingestion;
con-skin and/or eye contact.
^d DHHS 1992a.
^e Information is not available.
^f Not applicable, not found to be carcinogenic.
^g ORNL 1993b.
^h Mixture of compounds, therefore, a representative compound was selected for chemical group.
ⁱ DHHS 1992b.
^j ACGIH 1991.
^k Merck 1989a.
^l Lewis 1992a.
^m DHHS 1986a.
ⁿ EPA 1993c.
^o CFR 40, EPA 1992.
^p Patty's Industrial Hygiene and Toxicology.
^q Moderate explosion hazard in form of dust when exposed to flame.
^r IARC, International Agency for Research on Cancer.
^s Encyclopedia of Occupational Health, 1983.

^a NIOSH 1990a; ORNL 1993b.
^b Flammable liquids are classified by OSHA (29 CFR 1910.106) as follows:

- Class IA—Fl.P below 73 °F and BP below 100 °F;
- Class IB—Fl.P below 73 °F and BP at or above 100 °F;
- Class IC—Fl.P at or above 73 °F and below 100 °F;
- Class II—Fl.P at or above 100 °F and below 140 °F;
- Class IIIA—Fl.P at or above 140 °F and below 200 °F;
- Class IIIB—Fl.P at or above 200 °F.

^c Routes of exposure abbreviated as follows:

- inh—inhalation;
- abs—skin absorption;
- ing—ingestion;
- con—skin and/or eye contact.

^d DHHS 1992a.

^e Information is not available.

^f Not applicable, not found to be carcinogenic.

^g ORNL 1993b.

Note: CNS - central nervous system; CVS - cardiovascular system

Note: * - % by weight/volume, i.e. g/100ml.

Note: ** - at 68 °F unless indicated otherwise.

^h Mixture of compounds, therefore, a representative compound was selected for chemical group.

ⁱ DHHS 1992b.

^j ACGIH 1991.

^k Merck 1989a.

^l Lewis 1992a.

^m DHHS 1986a.

ⁿ EPA 1993c.

^o CFR 40, EPA 1992.

^p Party's Industrial Hygiene and Toxicology.

^q Moderate explosion hazard in form of dust when exposed to flame.

^r IARC, International Agency for Research on Cancer.

^s Encyclopedia of Occupational Health, 1983.

TABLE E.3.3-1.—Regulated Exposure Limits [Page 1 of 9]

Compound	Chemical Abstracts Service No.	Reference ^a Dose (oral) (mg/kg/day)	Reference ^a Concentration (inhalation) (mg/m ³)	Cancer Class ^a	Slope Factor ^{a,b} (mg/kg/day) ⁻¹	Occupational Exposure Levels
Acetic acid	64-19-7	0.175	0.613 ^c	NA	None	OSHA-PEL: 25 mg/m ^{3d} ACGIH-TLV: 25 mg/m ³ , 37 mg/m ³ [STEL] ^e NIOSH-REL: same as above ^f
Acetone	67-64-1	1x10 ⁻¹	10.5 ^f	D	None	OSHA-PEL: 1,800 mg/m ³ and STEL of 2,400 mg/m ^{3d} ACGIH-TLV: same as above ^e NIOSH-REL: 590 mg/m ³ and a IDLH of 48,400 mg/m ^{3d}
Acetonitrile	75-05-8	6.0x10 ^{-3k}	0.021 ^c [0.050*]	NA	None	OSHA-PEL: 70 mg/m ³ , 105 mg/m ³ [15-min. STEL] ^d ACGIH-TLV: 67 mg/m ³ , 101 mg/m ³ [skin] [STEL] ^e NIOSH-REL: 34 mg/m ^{3d}
Acetylene	74-86-2	18.63 ^c	65.22 ^c	NA	None	OSHA-PEL: 2,662 mg/m ^{3f} ACGIH-TLV: Simple Asphyxiant NIOSH-REL: 2,708 mg/m ^{3f}
Acrolein	107-02-8	2.0x10 ^{-2*}	7.0x10 ^{-2e}	C	None	OSHA-PEL: 0.25 mg/m ³ and STEL of 0.8 mg/m ^{3d} ACGIH-TLV: 0.23 mg/m ^{3e} NIOSH-REL: 0.25 mg/m ^{3d}
Acrylonitrile	107-13-1	1.0x10 ^{-3*}	2.0x10 ^{-3k}	B ₁ ^k	0.24 (inhal)	OSHA-PEL: 4.42 mg/m ³ ACGIH-TLV: 4.3 mg/m ³ NIOSH: IDLH = 1,105 mg/m ³
Aliphatic alcohol (n-butyl alcohol)	71-36-3	0.1 ^k	0.35 ^c	D	None	OSHA-PEL: 150 mg/m ³ (skin) ACGIH-TLV: 152 mg/m ³ (ceiling) NIOSH-REL: 150 mg/m ³ (ceiling)
Aliphatic hydrocarbons (e.g., cyclohexane)	110-82-7	7.35 [PNL]	25.7 ^c	NA	None	OSHA-PEL: 1050 mg/m ^{3e} ACGIH-TLV: 1030 mg/m ^{3e} NIOSH-REL: 1050 mg/m ^{3d}
Ammonia	7664-41-7	0.0286 ^j	0.1 [*]	NA	None	OSHA-PEL: 27 mg/m ^{3d} ACGIH-TLV: 17 mg/m ³ and a 15 minute STEL of 27 mg/m ^{3d} NIOSH-REL: 18 mg/m ³ and a 15 minute STEL of 27 mg/m ^{3d}
Antimony	7440-36-0	4.0x10 ^{-4#}	1.4x10 ^{-3c}	NA	None	OSHA-PEL: 0.5 mg/m ^{3d} ACGIH-TLV: 0.5 mg/m ^{3e} NIOSH-REL: 0.5 mg/m ³ and IDLH of 80 mg/m ^{3d}
Aromatic hydrocarbons						
benzo (a) pyrene	50-32-8	NA	NA	B2k	5.79 ^k	OSHA-PEL: 0.2 mg/m ³ ACGIH-TLV: suspected human carcinogen NIOSH-REL: controlled as a carcinogen
Chrysene	218-01-9	NA	NA	B2k		
Pyrene	129-00-0	3x10 ⁻²	1.05x10 ^{-1c}	Dk		
Aromatic petroleum distillate (benzo[a]pyrene)	50-32-8	1.4x10 ^{-3l}	4.4x10 ^{-3c}	B ₂	5.79 ^k	OSHA-PEL: 0.2 mg/m ³ ACGIH-TLV: Suspect Human Carcinogen NIOSH-REL: Controlled as Carcinogen

TABLE E.3.3-1.—Regulated Exposure Limits [Page 2 of 9]

Compound	Chemical Abstracts Service No.	Reference ^a Dose (oral) (mg/kg/day)	Reference ^a Concentration (inhalation) (mg/m ³)	Cancer Class ^a	Slope Factor ^a (mg/kg/day) ⁻¹	Occupational Exposure Levels
Benzene	71-43-2	0.224 ^b	0.783 ^c	A	.029 (oral)	OSHA-PEL: 3.25 mg/m ³ and a STEL of 16.25 ACGIH-TLV: 32 mg/m ³ NIOSH-REL: 0.325 mg/m ³ and a IDLH of 9750 mg/m ³
Bromoform	75-25-2	2x10 ⁻²	6.99x10 ⁻⁴	B ₂ ^k	0.0079 ^k	OSHA-PEL: 5 mg/m ³ ^{3d} ACGIH-TLV: 5.2 mg/m ³ ^{3e} NIOSH-REL: 5 mg/m ³ ^{3d}
2-Butoxyethanol	111-76-2	8.47x10 ⁻¹ ^b	2.96 ^c	NA	None	OSHA-PEL: 240 mg/m ³ ACGIH-TLV: 121 mg/m ³ NIOSH-REL: 120 mg/m ³
n-Butyl acetate	123-86-4	4.97 ^b	17.4 ^c	NA	None	OSHA-PEL: 710 mg/m ³ , 950 mg/m ³ [15-min. STEL] ^g ACGIH-TLV: same as above ^h NIOSH-REL: same as above ^f
n-Butyl alcohol	71-36-3	1.05 ^b	3.675 ^c	D	None	OSHA-PEL: 150 mg/m ³ [skin] [ceiling] ^d ACGIH-TLV: 152 mg/m ³ [ceiling] ^e NIOSH-REL: 150 mg/m ³ [skin] [ceiling] ^d
Cadmium	7440-43-9	5x10 ⁻⁴	1.75x10 ⁻³ ^c	B ₁	i	OSHA-PEL: 0.2 mg/m ³ ^{3d} ACGIH-TLV: 0.05 mg/m ³ ^{3e} NIOSH-IDLH: 50 mg/m ³ ^{3d}
Cadmium oxide	1306-19-0	7x10 ⁻³ ^b	2.5x10 ⁻² ^c	NA	None	OSHA-PEL: 0.1 mg/m ³ ^{3d} ACGIH-TLV: 0.05 mg/m ³ ^{3e} NIOSH-REL: 2 mg/m ³ and an IDLH of 9 mg/m ³ ^{3d}
Carbon tetrachloride	56-23-5	7x10 ⁻⁴	2.5x10 ⁻³	B ₂	1.3x10 ⁻¹ (oral)* 5.3x10 ⁻² (inhal)*	OSHA-PEL: 12.6 mg/m ³ [8-hr TWA] ^d ACGIH: 31 mg/m ³ [skin] ^e NIOSH-REL: 12.6 mg/m ³ [60-min ceiling limit] ^d
Chlorine	7782-50-5	0.011 [PNL]	3.9x10 ⁻² ^c	NA	None	OSHA-PEL: 1.5 mg/m ³ and a 15-minute STEL of 3 mg/m ³ ^{3d} ACGIH-TLV: 1.5 mg/m ³ ^{3e} NIOSH-REL: 1.5 mg/m ³ ^{3d}
Chlorobenzene	108-90-7	2x10 ⁻² ^k	2x10 ⁻² [*] (alternate method)	D	None	OSHA-PEL: 350 mg/m ³ ^{3d} ACGIH-TLV: 46 mg/m ³ ^{3e} NIOSH-IDLH: 11,232 mg/m ³ ^{3d}
Chlorodifluoromethane (Freon 22)	75-45-6	24.8 ^b	86.7 ^c	NA	None	OSHA-PEL: 3,500 mg/m ³ ACGIH-TLV: 3,540 mg/m ³ NIOSH-REL: NA
Chloroform	67-66-3	1x10 ⁻²	0.03497	B ₂	0.0061 (oral) 0.08 (inhal)	OSHA-PEL: 240 mg/m ³ ^{3g} OSHA-TWA: 9.78 mg/m ³ ^{3d} ACGIH-TLV: 49 mg/m ³ ^{3e} NIOSH-IDLH: 4,960 mg/m ³ ^{3d}

TABLE E.3.3-1.—Regulated Exposure Limits [Page 3 of 9]

Compound	Chemical Abstracts Service No.	Reference ^a Dose (oral) (mg/kg/day)	Reference ^a Concentration (inhalation) (mg/m ³)	Cancer Class ^a	Slope Factor ^a (mg/kg/day) ⁻¹	Occupational Exposure Levels
Cleaning solvent (butyl lactate)	138-22-7	0.208 ^b	0.73 ^c	NA	NA	OSHA-PEL: 30 mg/m ^{3g} ACGIH-TLV: 30 mg/m ^{3e}
Cyanogen	460-19-5	4x10 ^{-2k}	0.14 ^c	NA	None	OSHA-PEL: NA ACGIH-TLV: 21 mg/m ³ OSHA-TWA: 20 mg/m ³
Cyclohexane	110-82-7	7.35 ^b	25.7 ^c	NA	None	OSHA-PEL: 1,050 mg/m ^{3f} ACGIH-TLV: 1,030 mg/m ^{3f} NIOSH-REL: 1,050 mg/m ^{3f}
Diacetone alcohol	123-42-2	1.68 ^l	5.88 ^c	NA	None	OSHA-PEL: 240 mg/m ³ ACGIH-TLV: 240 mg/m ³ NIOSH-REL: 240 mg/m ³
Dibutyl phthalate	84-74-2	0.1	0.3497	D	None	OSHA-PEL: 5 mg/m ^{3d} ACGIH-TLV: 5 mg/m ^{3e}
Dichloropropene (1,3)	542-75-6	3x10 ⁻⁴	2x10 ⁻²	B ₂	0.18	OSHA-PEL: 5 mg/m ^{3g} ACGIH-TLV: 4.5 mg/m ^{3e}
Diesel exhaust	i	i	i	i	i	OSHA-PEL: i ACGIH-TLV: i NIOSH-REL: i
Diethylene glycol ethyl ether	111-90-0	2.0 [*]	7.0 ^c	NA	None	OSHA-PEL: NA ACGIH-TLV: NA RTECS: 2,500 mg/kg (rabbit), intravenous LD ₅₀ : 6600 mg/kg oral LD ₅₀ (mouse)
Dimethylformamide	68-12-2	0.1 [*]	0.35 ^c	NA	None	NIOSH-REL: 30 mg/m ³ [8-hr TWA] ^d OSHA-PEL: same as above ^g ACGIH-TLV: same as above ^e
Dinitrotoluene (2,4)	121-14-2	2x10 ⁻³	6.9x10 ⁻³	B ₂ (mixture)	None	OSHA-PEL: 1.5 mg/m ³ ACGIH-TLV: 0.15 mg/m ³ NIOSH-REL: Reduce to lowest level
Diocetyl phthalate (Di(2-ethylhexyl) phthalate)	117-81-7	0.02	0.07 ^c	B ₂	0.014 (oral)	OSHA-PEL: 5 mg/m ³ 10 mg/m ³ [15-min. STEL] ^d ACGIH-TLV: 5 mg/m ^{3e} NIOSH-REL: 5 mg/m ³ (skin) ^d
Epoxy solvent (e.g., toluene)	108-88-3	2x10 ^{-1k}	4.0x10 ^k	NA	None	OSHA-PEL: 375 mg/m ³ ACGIH-TLV: 188 mg/m ³ NIOSH-REL: 375 mg/m ³
Ethyl benzene	100-41-4	0.1	1	D	None	OSHA-PEL: 435 mg/m ^{3d} ACGIH-TLV: 434 mg/m ^{3e} NIOSH-REL: 435 mg/m ^{3d} and an IDLH of 8,820 mg/m ^{3d}

TABLE E.3.3-1.—Regulated Exposure Limits [Page 4 of 9]

Compound	Chemical Abstracts Service No.	Reference ^a Dose (oral) (mg/kg/day)	Reference ^a Concentration (inhalation) (mg/m ³)	Cancer Class ^a	Slope Factor ^a (mg/kg/day) ⁻¹	Occupational Exposure Levels
Ethyl acetate	141-78-6	0.9 [9.0*]	3.15 ^c	NA	None	OSHA-PEL: 1,400 mg/m ^{3d} ACGIH-TLV: same as above ^e NIOSH-REL: same as above ^d
Ethyl alcohol (ethanol)	64-17-5	13.2 ^b	46.1 ^c	NA	None	OSHA-PEL: 1,900 mg/m ^{3g} ACGIH-TLV: 1,880 mg/m ^{3e}
Ethylene oxide	75-21-8	0.0128	0.0447	IARC EPA B ₁	0.35 (inhal)	OSHA-PEL: 1.83 mg/m ^{3f} ACGIH-TLV: 1.8 mg/m ^{3e} NIOSH-REL: 0.18 mg/m ³ and an IDLH of 1,464 mg/m ^{3f}
Fiske 604	i	i	i	i	i	OSHA-PEL: i ACGIH-TLV: i NIOSH-REL: i
Formaldehyde	50-00-0	0.2	none	B ₁	4.5x10 ⁻² (inhal)* unit risk factor: 1.3x10 ⁻⁵ (inhal)	OSHA-PEL: 1 ppm with a 15 min. STEL of 2 ppm ^d ACGIH-TLV: 1 ppm ^e NIOSH-REL: 0.016 ppm with a 15 minute STEL of 0.1 ppm (Ceiling) ^d
Formic acid	64-18-6	2	6.994	NA	NA	OSHA-PEL: 9 mg/m ^{3d} ACGIH-TLV: 9.4 mg/m ^{3e} NIOSH-REL: 9 mg/m ³ and an IDLH of 57.3 mg/m ^{3d}
Freon 22 (chlorodifluoromethane)	75-45-6	24.8 ^b	86.7 ^c	NA	None	OSHA-PEL: 3,500 mg/m ^{3d} ACGIH-TLV: 3,540 mg/m ^{3e} NIOSH-REL: NA
Freon 12 (dichlorodifluoromethane)	75-71-8	0.2 ^b	0.7*	NA	None	OSHA-PEL: 4,950 mg/m ^{3d} ACGIH-TLV: same as above ^e NIOSH-REL: same as above ^d
Freon 11 (trichlorofluoromethane)	75-69-4	0.3	0.7 ^c [0.2*]	NA	None	OSHA-PEL: 5,620 mg/m ³ , 5,620 mg/m ³ [ceiling] ^d ACGIH-TLV: same as above ^e NIOSH-REL: same as above ^d
Freon 113 (trichlorotrifluoroethane)	76-13-1	30	105 ^c	NA	None	OSHA-PEL: 7,600 mg/m ³ , 9,500 mg/m ³ [ST] ^d ACGIH-TLV: 7,670 mg/m ³ , 9,590 mg/m ³ [STEL] ^e NIOSH-REL: 7,600 mg/m ³ , 9,500 mg/m ³ [STEL] ^f
Freon TF (trichlorotrifluoromethane)	75-69-4	3.0x10 ^{-1k}	1.05 ^c	NA	None	OSHA-PEL: 5,600 mg/m ³ ACGIH-TLV: 5,620 mg/m ³ NIOSH-REL: 5,600 mg/m ³
Heptane	142-82-5	11.5 ^b	40.3 ^c	D	None	OSHA-PEL: 1,600 mg/m ³ , 2,000 mg/m ³ [STEL] ^d ACGIH-TLV: 1,640 mg/m ³ , 2,050 mg/m ³ [STEL] ^e NIOSH-REL: 350 mg/m ³ , 1,800 mg/m ³ [15-min. ceiling] ^f

TABLE E.3.3-1.—Regulated Exposure Limits [Page 5 of 9]

Compound	Chemical Abstracts Service No.	Reference ^a Dose (oral) (mg/kg/day)	Reference ^a Concentration (inhalation) (mg/m ³)	Cancer Class ^a	Slope Factor ^a (mg/kg/day) ⁻¹	Occupational Exposure Levels
Hexane	110-54-3	6x10 ⁻² j	0.2	D	None	OSHA-PEL: 1,800 mg/m ³ ACGIH-TLV: 176 mg/m ³ ^e NIOSH-REL: 180 mg/m ³ and an IDLH of 17,900 mg/m ³ ^{3d}
Hydrocarbons (n-heptane)	142-82-5	11.5 ^b	40.25 ^c	D	None	OSHA-PEL: 1,600 mg/m ³ ^{3d} ACGIH-TLV: 1,640 mg/m ³ NIOSH-REL: 350 mg/m ³
Hydrochloric acid	7647-01-0	2x10 ⁻³ j	7x10 ⁻³ a [PNL]	NA	None	OSHA-PEL: 7 mg/m ³ ^{3h} ACGIH-TLV: 7.5 mg/m ³ [ceiling] ^e NIOSH-REL: 7 mg/m ³ ^{3f}
Hydrofluoric acid	7664-39-3	0.018 ^b	0.063 ^c	NA	None	OSHA-PEL: 2.5 mg/m ³ , 5 mg/m ³ [STEL] ^d ACGIH-TLV: 2.6 mg/m ³ [ceiling] ¹ NIOSH-REL: 2.5 mg/m ³ , 5 mg/m ³ [STEL] ^{3g}
Hydrogen cyanide	74-90-8	2.0x10 ⁻² k	7.0x10 ⁻² c	NA	None	OSHA-PEL: 11 mg/m ³ ACGIH-TLV: 11 mg/m ³ NIOSH-REL: 5 mg/m ³
Hydrogen fluoride	7664-39-3	6x10 ⁻² [PNL]	0.21 ^c	NA	None	OSHA-PEL: 2.5 mg/m ³ , 5 mg/m ³ , 15 STEL ACGIH-TLV: 2.6 mg/m ³ ^{3e} NIOSH-REL: 2.5 mg/m ³ and an IDLH of 24.9 mg/m ³
Hydrogen sulfide	7783-06-4	3x10 ⁻³ k	9x10 ⁻⁴ k	NA	None	OSHA-PEL: 28.4 mg/m ³ , the TWA is 14 mg/m ³ ^{3d} ACGIH-TLV: 14 mg/m ³ , and the STEL is: 21 mg/m ³ ^{3e} NIOSH-REL: 15 mg/m ³ , the IDLH is 426 mg/m ³ ^{3d}
Isobutane (2 methyl propane)	75-28-5	10.01 ^m	35.035 ^c	NA	None	OSHA-PEL: NA ACGIH-TLV: NA RTECS-LD ₅₀ : 1,898 mg/m ³ ^{3s}
Isobutyl acetate	110-19-0	4.9 ^p	17.15 ^c	NA	None	OSHA-PEL: 300 mg/m ³ ACGIH-TLV: 700 mg/m ³ NIOSH-REL: 700 mg/m ³
Isopropyl alcohol	67-63-0	6.9 [PNL]	24.15 ^c	NA	None	OSHA-PEL: 980 mg/m ³ [8-hr TWA], ^d 1,225 mg/m ³ , [15-min ST limit] ^d ACGIH-TLV: same as above ^e NIOSH-REL: same as above ^d
Manganese	7439-96-5	0.14	5x10 ⁻³ k	D ^k	None	OSHA-PEL: 5 mg/m ³ , TWA = 1 mg/m ³ ^{3d} , 3 mg/m ³ [STEL] ACGIH-TLV: 2 mg/m ³ ^{3e} , 5 mg/m ³ ^{3e} [Dust] ¹ , 1 mg/m ³ ^{3e} [Fume] ^{3e} NIOSH-REL: 1 mg/m ³ ^{3d}
Mercury (mercury, inorganic)	7439-97-6	3x10 ⁻⁴ *	3x10 ⁻⁴ *	D ^k	None	OSHA-PEL: 0.05 mg/m ³ ^{3g} , 0.01 mg/m ³ [Alkyl. cpds.], ¹ 0.01 mg/m ³ [Aryl. cpds.], ¹ NIOSH-REL: 0.05 mg/m ³ [8 hr TWA] [skin] ^d
Methane	74-82-8	NA	NA	NA	NA	Simple asphyxiant ¹

TABLE E.3.3-1.—Regulated Exposure Limits [Page 6 of 9]

Compound	Chemical Abstracts Service No.	Reference ^a Dose (oral) (mg/kg/day)	Reference ^a Concentration (inhalation) (mg/m ³)	Cancer Class ^a	Slope Factor ^a (mg/kg/day) ⁻¹	Occupational Exposure Levels
Methanol	67-56-1	5x10 ⁻¹	1.75 ^c	NA	None	OSHA-PEL: 260 mg/m ³ , 325 mg/m ³ [STEL] [skin] ^g ACGIH-TLV: 262 mg/m ³ , 328 mg/m ³ [STEL] ^g NIOSH-REL: 260 mg/m ³ [skin], 325 mg/m ³ [ceiling] [skin] ^f
Methyl bromide	74-83-9	0.133 ^b	0.465 ^c	NA	None	OSHA-PEL: 20 mg/m ³ ^g ACGIH-TLV: 19 mg/m ³ (SKIN) ^g NIOSH-REL: Reduce to lowest level, the IDLH is 7900 mg/m ³
Methylene chloride	75-09-2	6x10 ⁻² *	0.21 ^c	B ₂	7.5x10 ⁻³ (oral)	OSHA-PEL: 1,765 mg/m ³ [8-hr TWA], 3500 mg/m ³ [ceiling] ^d ACGIH-TLV: 174 mg/m ³ ^c NIOSH-REL: reduce exposure to lowest feasible concentration ^d
Methyl ethyl ketone (2-butanone)	78-93-3	0.6*	0.21 ^c	D	None	OSHA-PEL: 590 mg/m ³ [8-hr TWA], 885 mg/m ³ [15-min ST limit] ^d ACGIH-TLV: same as above ^d NIOSH-REL: same as above ⁱ
Methyl isobutyl ketone	108-10-1	0.05*	0.175 ^c	NA	None	OSHA-PEL: 205 mg/m ³ , 300 mg/m ³ [STEL] ^d ACGIH-TLV: 205 mg/m ³ , 300 mg/m ³ [STEL] ^e NIOSH-REL: 205 mg/m ³ , 300 mg/m ³ [STEL] ^f
Methyl-tert-butyl ether	1634-04-4	0.143 ^j	0.5 ^k	NA	None	OSHA-PEL: 1 ⁱ ACGIH-TLV: 1 ⁱ NIOSH-REL: 1 ⁱ
Naphtha	8030-30-6	8.4 ^b	29.4 ^c	NA	None	OSHA-PEL: 400 mg/m ³ ^{3d} ACGIH-TLV: 1,200 mg/m ³ ^{3h} NIOSH-REL: 400 mg/m ³ ^{3d}
Naphthalene	91-21-3	4x10 ⁻³ #	0.0139 ^c	D	None	OSHA-PEL: 50 mg/m ³ ^{3d} , 75 mg/m ³ [STEL] ^d ACGIH-TLV: 52 mg/m ³ ^{3e} , 79 mg/m ³ [STEL] ^e NIOSH-REL: 50 mg/m ³ ^{3d}
Nickel	7440-02-0	2x10 ⁻²	0.02	A	0.84	OSHA-PEL: 0.1 mg/m ³ ^{3d} ACGIH-TLV: 1 mg/m ³ ^{3e} NIOSH-REL: 0.15 mg/m ³ ^{3d}
Nickel oxide	7440-02-0	3x10 ⁻⁴	1.2x10 ⁻³	NA	None	OSHA-PEL: 0.1 mg/m ³ ^{3d} ACGIH-TLV: 0.1 mg/m ³ ^{3e}
Nitric acid	7697-37-2	0.035 ^b	0.123 ^c	NA	None	OSHA-PEL: 5 mg/m ³ and a 15 minute STEL 10 mg/m ³ ^{3d} ACGIH-TLV: 5.2 mg/m ³ ^{3e} , 10mg/m ³ [STEL] ^e NIOSH-REL: same as above ^d
Nitrocellulose (cellulose tetranitrate)	9004-70-0	2.0x10 ⁻¹ m	7.0x10 ⁻¹ c	e	None	OSHA-PEL: NA ACGIH-TLV: NA RTECS-LD ₅₀ : >5g/kg (oral rat/mouse) ⁵

TABLE E.3.3-1.—Regulated Exposure Limits [Page 7 of 9]

Compound	Chemical Abstracts Service No.	Reference ^a Dose (oral) (mg/kg/day)	Reference ^a Concentration (inhalation) (mg/m ³)	Cancer Class ^a	Slope Factor ^a (mg/kg/day) ⁻¹	Occupational Exposure Levels
Perfluoroalkylether (isoflurane)	26675-46-7	1.3 ^h	4.6 ^m	e	None	OSHA-PEL: NA ACGIH-TLV: NA Sax/Japan TWA LC ₅₀ : Inhal Rat - 115,454 mg/m ^{3h}
Perfluoro compounds (e.g., tetra CFCs)	76-14-2	49 ^j	171.3	e	None	OSHA-PEL: 7,000 mg/m ³ ACGIH-TLV: 6,990 mg/m ³ NIOSH-REL: 7,000 mg/m ³
Phenol	108-95-2	0.6 [*]	2.098 ^e	D ^g	None	OSHA-PEL: 19 mg/m ^{3d} ACGIH-TLV: 19 mg/m ^{3e} NIOSH-REL: 19 mg/m ^{3d}
Phosphoric acid	7664-38-2	7x10 ⁻³	2.45x10 ^{-2 c}	NA	None	OSHA-PEL: 1 mg/m ^{3d} ACGIH-TLV: 1 mg/m ^{3e} NIOSH-REL: 1 mg/m ^{3d} and an IDLH of 10,000 mg/m ^{3d}
Propane	74-98-6	12.6 ^l	44.1 ^c	NA	None	OSHA-PEL: 1,800 mg/m ³ ACGIH-TLV: 1,800 mg/m ³ NIOSH-REL: 1,800 mg/m ³
Propylene dichloride	78-87-5	2.429 ^b	8.494 ^c	B ₂	0.068	OSHA-PEL: 350 mg/m ³ and a STEL of 510 mg/m ^{3d} ACGIH-TLV: 347 mg/m ^{3e} , 508 mg/m ³ [STEL] ^e NIOSH-IDLH: 9,400 mg/m ^{3d}
Propyl glycol methyl ether (propylene glycol monomethyl ether)	107-98-2	0.572 ^j	2 ^k	NA	None	OSHA-PEL: NA ACGIH-TLV: 369 mg/m ³ OSHA-TWA: 360 mg/m ³
Resins and formers (toluene-2,4-diisocyanate)	584-84-9	2.8x10 ^{-4 l}	9.8x10 ^{-4 c}	NA	None	OSHA-PEL: 0.04 mg/m ³ [8hr. TWA] ACGIH-TLV: 0.036 mg/m ³ NIOSH-REL: 0.04 mg/m ³
Sodium hydroxide	1310-73-2	1.4x10 ^{-2 b}	4.89x10 ^{-2 c}	NA	None	OSHA-PEL: 2 mg/m ^{3d} ACGIH-TLV: 2 mg/m ^{3e} NIOSH-REL: 2 mg/m ^{3d}
Sodium hypochlorite	7681-52-9	i	i	i	None	OSHA-PEL: i ACGIH-TLV: i NIOSH-REL: i
Sulfuric acid	7664-93-9	0.07 ^l	0.245 ^c	NA	None	OSHA-PEL: 1 mg/m ^{3g} ACGIH-TLV: 1 mg/m ^{3e} , 3 mg/m ³ [STEL] ^e NIOSH-REL: same as above ^e
Tetrachloroethane (1,1,2,2)	79-34-5	0.049 ^l	0.172 ^c	C ^k	0.2 [*]	OSHA-PEL: 7 mg/m ^{3d} ACGIH-TLV: 6.9 mg/m ^{3e} NIOSH-REL: 7 mg/m ^{3d} , the IDLH is 1,050 mg/m ^{3d}

TABLE E.3.3-1.—Regulated Exposure Limits [Page 8 of 9]

Compound	Chemical Abstracts Service No.	Reference ^a		Cancer Class ^a	Slope Factor ^a (mg/kg/day) ⁻¹	Occupational Exposure Levels
		Dose (oral) (mg/kg/day)	Concentration (inhalation) (mg/m ³)			
Tetrahydrofuran	109-99-9	4.13 ^l	14.455 ^c	NA	None	OSHA-PEL: 590 mg/m ³ ACGIH-TLV: 590 mg/m ³ , 737 mg/m ³ [STEL] ^e NIOSH-REL: 590 mg/m ³
Toluene	108-88-3	0.2 ^k	0.4 ^k	D	None	OSHA-PEL: 375 mg/m ³ , 560 mg/m ³ [ST] ^d ACGIH-TLV: 188 mg/m ³ [TWA] ^e NIOSH-REL: 375 mg/m ³ , 560 mg/m ³ [STEL] ^f
Trichloroethane (1,1,1)	71-55-6	3.5x10 ⁻² #	1.0*	D	None	OSHA-PEL: 1,900 mg/m ³ ^d ACGIH-TLV: 1,910 mg/m ³ ^{3e}
Trichloroethane (1,1,2)	79-00-5	4x10 ⁻² *	under review	C	5.7x10 ⁻² (inhal)*	OSHA-PEL: 45 mg/m ³ (skin) ^d ACGIH-TLV: 55 mg/m ³ ^{3e} NIOSH-REL: 45 mg/m ³ (skin) ^d
Trichloroethylene	79-01-6	7.35x10 ⁻³ #	0.013 (PNL)	B ₂	6.0x10 ⁻³ (inhal) 1.1x10 ⁻² (oral)	OSHA-PEL: 270 mg/m ³ STEL 1080 mg/m ³ ^d ACGIH-TLV: 270 mg/m ³ and STEL of 1,070 mg/m ³ ^{3e} NIOSH-REL: 1,370 mg/m ³ ^{3h}
Uranium (235, 238)	7440-61-1	0.003	0.0105 ^c	A	2.4x10 ⁻⁷ g/pCi (inhal)	OSHA-PEL: soluble cmpds-.05 mg/m ³ , insoluble cmpds-0.2 mg/m ³ ^{3d} ACGIH-TLV: .2 mg/m ³ ^{3e} NIOSH-REL: soluble .2 mg/m ³ , insoluble .05 mg/m ³ ^{3d}
Vinyl acetate	108-05-4	0.057 ^c	0.2 ^k	D	None	OSHA-PEL: 30 mg/m ³ STEL 60 mg/m ³ ^f ACGIH-TLV: 35 mg/m ³ STEL 70 mg/m ³ ^{3e} NIOSH-REL: 15 mg/m ³ ³ⁱ

TABLE E.3.3-1.—Regulated Exposure Limits [Page 9 of 9]

Compound	Chemical Abstracts Service No.	Reference ^a		Cancer Class ^a	Slope Factor ^a (mg/kg/day) ⁻¹	Occupational Exposure Levels
		Dose (oral) (mg/kg/day)	Concentration (inhalation) (mg/m ³)			
Vinyl chloride	75-01-4	1.82x10 ⁻²¹	6.37x10 ^{-2 c}	A	0.3 (inhal)	OSHA-PEL: 2.6 mg/m ^{3d} ACGIH-TLV: 13 mg/m ^{3e}
Xylene	1330-20-7	2*	7 ^c	D	None	OSHA-PEL: 435 mg/m ³ , 655 mg/m ³ [STEL] ^g ACGIH-TLV: 434 mg/m ^{3e} NIOSH-REL: 435 mg/m ³ , 655 mg/m ^{3d}

^a The majority of the Reference Dose and Reference Concentration values in this table were taken from the Integrated Risk Information System (EPA 1993c) for the particular chemical. In a few cases, values were copied from the Health Effects Assessment Summary Tables. Values from the HEAST tables are denoted with the symbol (*) (EPA 1993a). Values followed by the symbol (#) were taken from the Office of Drinking Water's Health Advisories. Values from Pacific Northwest Laboratories of Battelle 1991 are denoted as (PNL). The Cancer Class and Slope Factor are, likewise, from the Integrated Risk Information System unless indicated otherwise (EPA 1993c).

^b Reference Dose calculated from the ACGIH-TLV, formula from the Center for Risk Management, Oak Ridge National Lab (1992d) (DOE 1992).

^c Reference Concentration calculated from the Reference Dose, using formula from the Center for Risk Management, Oak Ridge National Lab (DOE, 1992).

^d NIOSH 1990a.

^e ACGIH 1992a.

^f DHHS 1992b.

^g 29 CFR 1910.

^h Lewis 1992a.

ⁱ Information is not available.

^j Reference Dose calculated from the value for the Reference Concentration.

^k ORNL 1993b.

^l Reference Dose calculated from the OSHA PEL/TWA.

^m Reference Dose calculated from the RTECS LD50.

ⁿ Reference Concentration calculated from the NIOSH REL.

^r Calculated from the PNL RFD value (3.0) using the ORNL method.

^s Registry of toxic effects of chemical substances, DHHS, NIOSH, 1982.

Note: NA - not applicable.

TABLE E.3.4-1.—Risk Assessments from Exposure to Hazardous Chemicals from No Action Operation at Idaho National Engineering Laboratory

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory			Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary MEI ^a		Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
					Annual (mg/m ³)	100 Meters 8 Hours (mg/m ³)				
Acetone	10,500	1,800	1,800	0	8.6x10 ⁻⁸	9.3x10 ⁻⁴	8.2x10 ⁻⁹	5.1x10 ⁻⁷	0	0
Ammonia	0.100	27	17	0	1.1x10 ⁻⁵	0.12	1.1x10 ⁻⁴	4.3x10 ⁻³	0	0
Nitric Acid	0.123	5	5	0	7.9x10 ⁻⁶	0.09	6.4x10 ⁻⁵	0.017	0	0
1,1,1-Trichloroethane (TCA)	1,000	1,900	1,900	0	3.6x10 ⁻⁶	0.04	3.6x10 ⁻⁶	2.0x10 ⁻⁵	0	0
Hazard Index ^f							1.7x10 ⁻⁴	0.021		
Total Cancer Risks ^g									0	0

^a MEI: maximally exposed individual of the public.

^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.

^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/Permissible Exposure Limit.

^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Cancer Risk for workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).

^f Hazard Index: sum of individual Hazard Quotients.

^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; INEL 1993a:5.

TABLE E.3.4-2.—Risk Assessments from Exposure to Hazardous Chemicals from Heavy Water Reactor Operation at Idaho National Engineering Laboratory

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	Boundary Annual MEI ^{a,b}	Worker 100 Meters 8 Hours	Boundary Annual MEI ^{a,d}	Worker 100 Meters 8 Hours ^e
Acetylene	66.28	2,708	2,708	None	2.3x10 ⁻⁶	0.025	3.4x10 ⁻⁸	9.0x10 ⁻⁶	0	0
Ethanol	46.1	1,900	1,880	None	8.5x10 ⁻⁷	9.2x10 ⁻³	1.8x10 ⁻⁸	4.8x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	2.3x10 ⁻⁶	0.03	0	0	0	0
Methanol	1.75	260	200	None	8.5x10 ⁻⁷	9.2x10 ⁻³	4.8x10 ⁻⁷	3.5x10 ⁻⁵	0	0
Nitric acid	0.123	5	5	None	4.3x10 ⁻⁶	0.046	3.5x10 ⁻⁵	9.3x10 ⁻³	0	0
1,1,1-Trichloroethane (TCA)	1.0	1,900	1,900	None	7.1x10 ⁻⁷	7.7x10 ⁻³	7.1x10 ⁻⁷	4.1x10 ⁻⁶	0	0
Trichlorotrifluoroethane (Freon 113)	105.0	7,600	7,600	None	3.0x10 ⁻⁵	0.33	2.9x10 ⁻⁷	4.3x10 ⁻⁵	0	0
Hazard Index^f										
Total Cancer Risk^g							3.6x10 ⁻⁵	9.4x10 ⁻³	0	0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permisible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual Hazard Quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; INEL 1993a:5.

TABLE E.3.4-3.—Risk Assessments from Exposure to Hazardous Chemicals from Modular High Temperature Gas-Cooled Reactor Operation at Idaho National Engineering Laboratory

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory			Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg·kg/day)	Boundary		Boundary Annual	Worker 100 Meters 8 Hours ^c	Boundary Annual	Worker 100 Meters 8 Hours ^c
					MEI ^a Annual (mg/m ³)	100 Meters 8 Hours (mg/m ³)				
Acetylene	66.28	2,708	2,708	None	2.3x10 ⁻⁶	0.03	3.4x10 ⁻⁸	9.0x10 ⁻⁶	0	0
Ethanol	46.1	1,900	1,880	None	8.5x10 ⁻⁷	9.2x10 ⁻³	1.8x10 ⁻⁸	4.8x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	2.3x10 ⁻⁶	0.03	0	0	0	0
Methanol	1.75	260	200	None	8.5x10 ⁻⁷	9.2x10 ⁻³	4.8x10 ⁻⁷	3.5x10 ⁻⁵	0	0
1,1,1-Trichloroethane (TCA)	1.0	1,900	1,900	None	2.3x10 ⁻⁷	0.03	2.3x10 ⁻⁷	1.3x10 ⁻⁵	0	0
Hazard Index ^f							7.7x10 ⁻⁷	6.2x10 ⁻⁵	0	0
Total Cancer Risk ^g							0	0	0	0

^a MEI: maximally exposed individual of the public.

^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.

^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.

^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.571 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).

^f Hazard Index: sum of individual Hazard Quotients.

^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; INEL 1993a.5.

TABLE E.3.4-4.—Risk Assessments from Exposure to Hazardous Chemicals from Advanced Light Water Reactor Operation at Idaho National Engineering Laboratory

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
Acetone	10.5	1,800	1,800	None	7.1x10 ⁻⁶	0.08	6.8x10 ⁻⁷	4.3x10 ⁻⁵	0	0
Acetylene	66.28	2,708	2,708	None	2.3x10 ⁻⁶	0.03	3.4x10 ⁻⁸	9.0x10 ⁻⁶	0	0
Ammonia	0.1	27	17	None	3.7x10 ⁻⁶	0.04	3.7x10 ⁻⁵	1.5x10 ⁻³	0	0
Ethanol	46.1	1,900	1,880	None	8.5x10 ⁻⁷	9.2x10 ⁻³	1.8x10 ⁻⁸	4.8x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	2.3x10 ⁻⁶	0.03	0	0	0	0
Methanol	1.75	260	200	None	8.5x10 ⁻⁷	9.2x10 ⁻³	4.8x10 ⁻⁷	3.5x10 ⁻⁵	0	0
Nitric acid	0.123	5	5	None	5.0x10 ⁻⁵	0.54	4.1x10 ⁻⁴	0.11	0	0
1,1,1-Trichloroethane (TCA)	1.0	1,900	1,900	None	9.8x10 ⁻⁶	0.11	9.8x10 ⁻⁶	5.6x10 ⁻⁶	0	0
Hazard Index ^f							4.5x10 ⁻⁴	0.11		
Total Cancer Risk ^g									0	0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual Hazard Quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; INEL 1993a:5; FDI Nov. 4, 1994, Log FO-94-0354.

TABLE E.3.4-5.—Risk Assessments from Exposure to Hazardous Chemicals from Accelerator Production of Tritium Operation at Idaho National Engineering Laboratory

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg-kg/day)	Boundary MEI ^a		Boundary MEI ^{a,b}		Boundary MEI ^{a,d}	
					Annual (mg/m ³)	Worker 8 Hours (mg/m ³)	Annual	Worker 8 Hours ^c	Annual	Worker 8 Hours ^e
Acetylene	66.28	2,708	2,708	None	2.3x10 ⁻⁶	0.03	3.4x10 ⁻⁸	9.0x10 ⁻⁶	0	0
Ethanol	46.1	1,900	1,880	None	8.5x10 ⁻⁷	9.2x10 ⁻³	1.8x10 ⁻⁸	4.8x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	2.3x10 ⁻⁶	0.03	0	0	0	0
Methanol	1.75	260	200	None	8.5x10 ⁻⁷	9.2x10 ⁻³	4.8x10 ⁻⁷	3.5x10 ⁻⁵	0	0
Hazard Index ^f							5.4x10 ⁻⁷	4.9x10 ⁻⁵		
Total Cancer Risk ^g									0	0

^a MEI: maximally exposed individual of the public.

^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.

^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.

^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).

^f Hazard Index: sum of individual Hazard Quotients.

^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; INEL 1993a:5.

TABLE E.3.4-6.—Risk Assessments from Exposure to Hazardous Chemicals from Tritium Recycling Operation at Idaho National Engineering Laboratory

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Value (mg/m ³)	Slope Factor (mg-kg/day)	Boundary MEI ^a		Boundary MEI ^{a,b}		Cancer Risk
					Annual (mg/m ³)	100 Meters 8 Hours (mg/m ³)	Annual	100 Meters 8 Hours ^c	
Acetylene	66.28	2,708	2,708	None	2.3x10 ⁻⁶	0.03	3.4x10 ⁻⁸	9.0x10 ⁻⁶	0
Ethanol	46.1	1,900	1,880	None	8.5x10 ⁻⁷	9.2x10 ⁻³	1.8x10 ⁻⁸	4.8x10 ⁻⁶	0
Methane (simple asphyxiant)	None	None	None	None	2.3x10 ⁻⁶	0.03	0	0	0
Methanol	1.75	260	200	None	8.5x10 ⁻⁷	9.2x10 ⁻³	4.8x10 ⁻⁷	3.5x10 ⁻⁵	0
Hazard Index^f							5.4x10⁻⁷	4.9x10⁻⁵	
Total Cancer Risk^g									0

^a MEI: maximally exposed individual of the public.

^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.

^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.

^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).

^f Hazard Index: sum of individual Hazard Quotients.

^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; INEL 1993a.5.

TABLE E.3.4-7.—Risk Assessments from Exposure to Hazardous Chemicals at Idaho National Engineering Laboratory—Summary Hazard Index and Total Cancer Risk

Technology ^a	Hazard Index		Total Cancer Risk	
	Boundary MEI ^{b,c} Annual	Worker 100 Meters 8 Hours ^b	Boundary MEI ^{d,e} Annual	Worker 100 Meters 8 Hours ^{d,f}
No Action	1.7×10^{-4}	0.021	0	0
Tritium Recycle	5.4×10^{-7}	4.9×10^{-5}	0	0
Heavy Water Reactor	3.6×10^{-5}	9.4×10^{-3}	0	0
Heavy Water Reactor and Tritium Recycling	3.7×10^{-5}	9.4×10^{-3}	0	0
Heavy Water Reactor, Tritium Recycling, and No Action	2.1×10^{-4}	0.031	0	0
Modular High Temperature Gas-Cooled Reactor	7.7×10^{-7}	6.2×10^{-5}	0	0
Modular High Temperature Gas-Cooled Reactor and Tritium Recycling	1.3×10^{-6}	1.1×10^{-4}	0	0
Modular High Temperature Gas-Cooled Reactor, Tritium Recycling, and No Action	1.8×10^{-4}	0.021	0	0
Advanced Light Water Reactor	4.5×10^{-4}	0.11	0	0
Advanced Light Water Reactor and Tritium Recycling	4.6×10^{-4}	0.11	0	0
Advanced Light Water Reactor, Tritium Recycling, and No Action	6.3×10^{-4}	0.13	0	0
Accelerator Production of Tritium	5.4×10^{-7}	4.9×10^{-5}	0	0
Accelerator Production of Tritium and Tritium Recycling	5.4×10^{-6}	9.8×10^{-5}	0	0
Accelerator Production of Tritium, Tritium Recycling, and No Action	1.8×10^{-4}	0.021	0	0

^a Combined Hazard Index and total cancer risk for these alternatives.

^b MEI: maximally exposed individual of the public.

^c Hazard Index: sum of individual Hazard Quotients.

^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Total Cancer Risk: sum of individual cancer risks.

^f Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (slope factor).

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; INEL 1993a:5.

TABLE E.3.4-8.—Risk Assessments from Exposure to Hazardous Chemicals from No Action Operation at Nevada Test Site

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold		Boundary MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
			Limit Value (mg/m ³)	Slope Factor (mg-kg/day)						
None	None	None	None	None	None	None	None	None	None	None
Hazard Index ^f										
Total Cancer Risk ^g										

^a MEI: maximally exposed individual of the public.

^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.

^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.

^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).

^f Hazard Index: sum of individual Hazard Quotients.

^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; NTS 1993a.4.

TABLE E.3.4-9.—Risk Assessments from Exposure to Hazardous Chemicals from Heavy Water Reactor Operation at Nevada Test Site

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory			Hazard Quotient			Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary		Worker 100 Meters 8 Hours (mg/m ³)	Boundary		Worker 100 Meters 8 Hours	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
					MEI ^a Annual (mg/m ³)	Annual (mg/m ³)		MEI ^{a,b} Annual	Annual			
Acetylene	66.28	2,708	2,708	None	3.9x10 ⁻⁷	8.4x10 ⁻³	8.4x10 ⁻³	5.8x10 ⁻⁹	3.1x10 ⁻⁶	3.1x10 ⁻⁶	0	0
Ethanol	46.1	1,900	1,880	None	1.4x10 ⁻⁷	3.2x10 ⁻³	3.2x10 ⁻³	3.1x10 ⁻⁹	1.7x10 ⁻⁶	1.7x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	3.9x10 ⁻⁷	8.4x10 ⁻³	8.4x10 ⁻³	0	0	0	0	0
Methanol	1.75	260	200	None	1.4x10 ⁻⁷	3.2x10 ⁻³	3.2x10 ⁻³	8.2x10 ⁻⁸	1.2x10 ⁻⁵	1.2x10 ⁻⁵	0	0
Nitric acid	0.123	5	5	None	7.3x10 ⁻⁷	0.016	0.016	5.9x10 ⁻⁶	3.2x10 ⁻³	3.2x10 ⁻³	0	0
1,1,1-Trichloroethane (TCA)	1.0	1,900	1,910	None	1.2x10 ⁻⁷	2.7x10 ⁻³	2.7x10 ⁻³	1.2x10 ⁻⁷	1.4x10 ⁻⁶	1.4x10 ⁻⁶	0	0
Trichlorotrifluoroethane (Freon 113)	105.0	7,600	7,670	None	5.2x10 ⁻⁶	0.11	0.11	4.9x10 ⁻⁸	1.5x10 ⁻⁵	1.5x10 ⁻⁵	0	0
Hazard Index^f								6.2x10 ⁻⁶	3.2x10 ⁻³		0	0
Total Cancer Risk^g											0	0

^a MEI: maximally exposed individual of the public.

^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.

^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.

^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).

^f Hazard Index: sum of individual Hazard Quotients.

^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; NTS 1993a:4.

TABLE E.3.4-10.—Risk Assessments from Exposure to Hazardous Chemicals Modular High Temperature Gas-Cooled Reactor Operation at Nevada Test Site

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary		Boundary		Boundary	
					MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
Acetylene	66.28	2,708	2,708	None	3.9x10 ⁻⁷	8.4x10 ⁻³	5.8x10 ⁻⁹	3.1x10 ⁻⁶	0	0
Ethanol	46.1	1,900	1,880	None	1.4x10 ⁻⁷	3.2x10 ⁻³	3.1x10 ⁻⁹	1.7x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	3.9x10 ⁻⁷	8.4x10 ⁻³	0	0	0	0
Methanol	1.75	260	200	None	1.4x10 ⁻⁷	3.2x10 ⁻³	8.2x10 ⁻⁸	1.2x10 ⁻⁵	0	0
1,1,1-Trichloroethane (TCA)	1.0	1,900	1,910	None	3.9x10 ⁻⁸	8.6x10 ⁻⁴	3.9x10 ⁻⁸	4.5x10 ⁻⁷	0	0
Hazard Index^f										
Total Cancer Risk^g							1.3x10 ⁻⁷	1.7x10 ⁻⁵	0	0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual Hazard Quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; NTS 1993a-4.

TABLE E.3.4-11.—Risk Assessments from Exposure to Hazardous Chemicals from Advanced Light Water Reactor Operation at Nevada Test Site

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory			Hazard Quotient			Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary		Worker 100 Meters 8 Hours (mg/m ³)	Boundary		Worker 100 Meters 8 Hours	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
					MEI ^a Annual (mg/m ³)	MEI ^{a,b} 100 Meters 8 Hours (mg/m ³)		MEI ^{a,b} Annual	MEI ^{a,b} 100 Meters 8 Hours			
Acetone	10.5	1,800	1,800	None	1.2x10 ⁻⁶	0.03	0	1.2x10 ⁻⁷	1.5x10 ⁻⁵	0	0	0
Acetylene	66.28	2,708	2,708	None	3.9x10 ⁻⁷	8.4x10 ⁻³	0	5.8x10 ⁻⁹	3.1x10 ⁻⁶	0	0	0
Ammonia	0.1	27	17	None	6.4x10 ⁻⁷	0.014	0	6.4x10 ⁻⁶	5.1x10 ⁻⁴	0	0	0
Ethanol	46.1	1,900	1,880	None	1.4x10 ⁻⁷	3.2x10 ⁻³	0	3.1x10 ⁻⁹	1.7x10 ⁻⁶	0	0	0
Methane (simple asphyxiant)	None	None	None	None	3.9x10 ⁻⁷	8.4x10 ⁻³	0	0	0	0	0	0
Methanol	1.75	260	200	None	1.4x10 ⁻⁷	3.2x10 ⁻³	0	8.2x10 ⁻⁸	1.2x10 ⁻⁵	0	0	0
Nitric acid	0.123	5	5	None	8.5x10 ⁻⁶	0.19	0	6.9x10 ⁻⁵	0.037	0	0	0
1,1,1-Trichloroethane (TCA)	1	1,900	1,900	None	1.7x10 ⁻⁶	3.7x10 ⁻²	0	1.7x10 ⁻⁶	1.9x10 ⁻⁵	0	0	0
Hazard Index^f								7.7x10⁻⁵	3.8x10⁻²		0	0
Total Cancer Risk^g												

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual Hazard Quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; NTS 1993a:4.

TABLE E.3.4-12.—Risk Assessments from Exposure to Hazardous Chemicals from Accelerator Production of Tritium Operation at Nevada Test Site

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg-kg/day)	Boundary		Boundary		Boundary	
					MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
Acetylene	66.28	2,708	2,708	None	3.9x10 ⁻⁷	8.4x10 ⁻³	5.8x10 ⁻⁹	3.1x10 ⁻⁶	0	0
Ethanol	46.1	1,900	1,880	None	1.4x10 ⁻⁷	3.2x10 ⁻³	3.1x10 ⁻⁹	1.7x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	3.9x10 ⁻⁷	8.4x10 ⁻³	0	0	0	0
Methanol	1.75	260	200	None	1.4x10 ⁻⁷	3.2x10 ⁻³	8.2x10 ⁻⁸	1.2x10 ⁻⁵	0	0
Hazard Index^f							9.1x10⁻⁸	1.7x10⁻⁵	0	0
Total Cancer Risk^g									0	0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual Hazard Quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; NTS 1993a:4.

TABLE E.3.4-13.—Risk Assessments from Exposure to Hazardous Chemicals from Tritium Recycling Operation at Nevada Test Site

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg-kg/day)	Boundary MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
Acetylene	66.28	2,708	2,708	None	3.9×10^{-7}	8.4×10^{-3}	5.8×10^{-9}	3.1×10^{-6}	0	0
Ethanol	46.1	1,900	1,880	None	1.4×10^{-7}	3.2×10^{-3}	3.1×10^{-9}	1.7×10^{-6}	0	0
Methane (simple asphyxiant)	None	None	None	None	3.9×10^{-7}	8.4×10^{-3}	0	0	0	0
Methanol	1.75	260	200	None	1.4×10^{-7}	3.2×10^{-3}	8.2×10^{-8}	1.2×10^{-5}	0	0
Hazard Index ^f							9.1×10^{-8}	1.7×10^{-5}	0	0
Total Cancer Risk ^g									0	0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual Hazard Quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; NTS 1993a:4.

TABLE E.3.4-14.—*Risk Assessments from Exposure to Hazardous Chemicals at Nevada Test Site—
Summary Hazard Index and Total Cancer Risk*

Technology ^a	Hazard Index		Total Cancer Risk	
	Boundary MEI ^{b,c} Annual	Worker 100 Meters 8 Hours ^b	Boundary MEI ^{d,e} Annual	Worker 100 Meters 8 Hours ^{d,f}
No Action	0	0	0	0
Tritium Recycle	9.1×10^{-8}	1.7×10^{-5}	0	0
Heavy Water Reactor	6.2×10^{-6}	3.2×10^{-3}	0	0
Heavy Water Reactor and Tritium Recycling	6.3×10^{-6}	3.2×10^{-3}	0	0
Heavy Water Reactor, Tritium Recycling, and No Action	6.3×10^{-6}	3.2×10^{-3}	0	0
Modular High Temperature Gas-Cooled Reactor	1.3×10^{-7}	1.7×10^{-5}	0	0
Modular High Temperature Gas-Cooled Reactor and Tritium Recycling	2.2×10^{-7}	3.4×10^{-5}	0	0
Modular High Temperature Gas-Cooled Reactor, Tritium Recycling and No Action	2.2×10^{-7}	3.4×10^{-5}	0	0
Advanced Light Water Reactor	7.7×10^{-5}	0.038	0	0
Advanced Light Water Reactor and Tritium Recycling	7.7×10^{-5}	0.038	0	0
Advanced Light Water Reactor, Tritium Recycling, and No Action	7.7×10^{-5}	0.038	0	0
Accelerator Production of Tritium	9.1×10^{-8}	1.7×10^{-5}	0	0
Accelerator Production of Tritium and Tritium Recycling	1.8×10^{-7}	3.4×10^{-5}	0	0
Accelerator Production of Tritium, Tritium Recycling, and No Action	1.8×10^{-7}	3.4×10^{-5}	0	0

^a Combined Hazard Index and total cancer risk for these alternatives.

^b MEI: maximally exposed individual of the public.

^c Hazard Index: sum of individual Hazard Quotients.

^d Cancer Risk for MEI: (emissions concentration) $\times$ (0.286 [converts concentration to doses]) $\times$ (slope factor).

^e Total Cancer Risk: sum of individual cancer risks.

^f Cancer Risk for Workers: (emissions for 8-hr) $\times$ (0.286 [converts concentrations to doses]) $\times$ (slope factor).

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; NTS 1993a:4; FDI Nov.4, 1994 Log #FO-94-0354.

TABLE E.3.4-15.—Risk Assessments from Exposure to Hazardous Chemicals from No Action Operation at Oak Ridge Reservation

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory			Hazard Quotient			Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	Boundary Annual MEI ^{a,b}	Worker 100 Meters 8 Hours ^c	Boundary Annual MEI ^{a,d}	Worker 100 Meters 8 Hours ^e	Annual	8 Hours ^e
Chlorine	0.004	1.5	1.5	None	3.0x10 ⁻⁴	0.06	0.08	0.04	0	0	0	0
Chlorodifluoromethane (Freon 22)	86.7	3,540	3,540	None	6.4x10 ⁻⁴	0.12	7.3x10 ⁻⁶	3.4x10 ⁻⁵	0	0	0	0
Dichlorodifluoromethane (Freon 12)	0.7	4,950	4,950	None	5.6x10 ⁻⁴	0.11	8.0x10 ⁻⁴	2.2x10 ⁻⁵	0	0	0	0
Hydrogen chloride	0.007	7	7	None	1.3x10 ⁻³	0.25	0.18	0.04	0	0	0	0
Methanol	1.75	260	200	None	4.8x10 ⁻³	0.92	2.7x10 ⁻³	3.6x10 ⁻³	0	0	0	0
Nitric acid	0.123	5	5	None	1.7x10 ⁻³	0.33	0.01	0.07	0	0	0	0
Sulfuric acid	0.025	1	1	None	4.5x10 ⁻⁴	0.09	0.02	0.09	0	0	0	0
Tetrachloroethylene (PERC)	0.035	170	None	None	2.2x10 ⁻³	0.43	0.06	2.5x10 ⁻³	0	0	0	0
1,1,1-Trichloroethane (TCA)	1	1	1,900	None	1.4x10 ⁻⁴	0.03	1.4x10 ⁻⁴	0.03	0	0	0	0
Trichlorotrifluoroethane (Freon 113)	105	7,600	7,670	None	5.0x10 ⁻⁴	0.10	4.8x10 ⁻⁶	1.3x10 ⁻⁵	0	0	0	0
Trichlorofluoromethane (Freon 11)	1.05	5,620	5,620	None	1.5x10 ⁻³	0.28	1.4x10 ⁻³	5.0x10 ⁻⁵	0	0	0	0
Hazard Index^f							0.36	0.26			0	0
Total Cancer Risk^g												

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual Hazard Quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; ORR 1993a-8.

TABLE E.3.4-16.—Risk Assessments from Exposure to Hazardous Chemicals from Heavy Water Reactor Operation at Oak Ridge Reservation

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory				Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg·kg/day)	Boundary MEI ^a		Worker 100 Meters 8 Hours		Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
					Annual (mg/m ³)	Annual (mg/m ³)	Annual (mg/m ³)	(mg/m ³)				
Acetylene	66.28	2,708	2,708	None	1.1x10 ⁻⁴	0.02	1.6x10 ⁻⁶	7.4x10 ⁻⁶	0	0	0	0
Ethanol	46.1	1,900	1,880	None	3.9x10 ⁻⁵	7.5x10 ⁻³	8.5x10 ⁻⁷	4.0x10 ⁻⁶	0	0	0	0
Methane (simple asphyxiant)	None	None	None	None	1.1x10 ⁻⁴	0.02	0	0	0	0	0	0
Methanol	1.75	260	200	None	3.9x10 ⁻⁵	7.5x10 ⁻³	2.2x10 ⁻⁵	2.9x10 ⁻⁵	0	0	0	0
Nitric acid	0.12	5	5	None	2.0x10 ⁻⁴	0.04	1.6x10 ⁻³	7.6x10 ⁻³	0	0	0	0
1,1,1-Trichloroethane (TCA)	1	1,900	1,910	None	3.3x10 ⁻⁵	6.3x10 ⁻³	3.3x10 ⁻⁵	3.3x10 ⁻⁶	0	0	0	0
Trichlorotrifluoroethane (Freon 113)	105	7,600	7,670	None	1.4x10 ⁻³	0.27	1.3x10 ⁻⁵	3.5x10 ⁻⁵	0	0	0	0
Hazard Index^f												
Total Cancer Risk^g									1.7x10⁻³	7.7x10⁻³	0	0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual Hazard Quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; ORR 1993a;8.

TABLE E.3.4-17.—Risk Assessments from Exposure to Hazardous Chemicals from Modular High Temperature Gas-Cooled Reactor Operation at Oak Ridge Reservation

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory			Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary MEI ^a		Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
					Annual (mg/m ³)	8 Hours (mg/m ³)				
Acetylene	66.28	2,708	2,708	None	1.1x10 ⁻⁴	0.02	9.6x10 ⁻⁵	0.02	0	0
Ethanol	46.1	1,900	1,880	None	3.9x10 ⁻⁵	7.5x10 ⁻³	4.8x10 ⁻⁵	9.1x10 ⁻³	0	0
Methane (simple asphyxiant)	None	None	None	None	1.1x10 ⁻⁴	0.02	9.6x10 ⁻⁵	0.02	0	0
Methanol	1.75	260	200	None	3.9x10 ⁻⁵	7.5x10 ⁻³	4.8x10 ⁻⁵	9.1x10 ⁻³	0	0
1,1,1-Trichloroethane (TCA)	1	1,900	1,910	None	1.1x10 ⁻⁵	2.1x10 ⁻³	1.1x10 ⁻⁵	2.1x10 ⁻³	0	0
Hazard Index ^f							3.0x10 ⁻⁴	0.057	0	0
Total Cancer Risk ^g										

^a MEI: maximally exposed individual of the public.

^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.

^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.

^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).

^f Hazard Index: sum of individual Hazard Quotients.

^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; ORR 1993a:8.

TABLE E.3.4-18.—Risk Assessments from Exposure to Hazardous Chemicals from Advanced Light Water Reactor Operation at Oak Ridge Reservation

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory				Hazard Quotient				Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg-kg/day)	Boundary MEI ^a		Worker 100 Meters 8 Hours (mg/m ³)	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours	
					Annual (mg/m ³)	Annual (mg/m ³)								
Acetone	10.5	1,800	1,800	None	3.3x10 ⁻⁴	3.3x10 ⁻⁴	0.06	3.2x10 ⁻⁵	3.5x10 ⁻⁵	3.2x10 ⁻⁵	3.5x10 ⁻⁵	0	0	0
Acetylene	66.28	2,708	2,708	None	1.1x10 ⁻⁴	1.1x10 ⁻⁴	0.02	1.6x10 ⁻⁶	7.4x10 ⁻⁶	1.6x10 ⁻⁶	7.4x10 ⁻⁶	0	0	0
Ammonia	0.1	27	17	None	1.7x10 ⁻⁴	1.7x10 ⁻⁴	0.03	1.7x10 ⁻³	1.2x10 ⁻³	1.7x10 ⁻³	1.2x10 ⁻³	0	0	0
Ethanol	46.1	1,900	1,880	None	3.9x10 ⁻⁵	3.9x10 ⁻⁵	7.5x10 ⁻³	8.5x10 ⁻⁷	4.0x10 ⁻⁶	8.5x10 ⁻⁷	4.0x10 ⁻⁶	0	0	0
Methane (simple asphyxiant)	None	None	None	None	1.1x10 ⁻⁴	1.1x10 ⁻⁴	0.02	0	0	0	0	0	0	0
Methanol	1.75	260	200	None	3.9x10 ⁻⁵	3.9x10 ⁻⁵	7.5x10 ⁻³	2.2x10 ⁻⁵	2.9x10 ⁻⁵	2.2x10 ⁻⁵	2.9x10 ⁻⁵	0	0	0
Nitric acid	0.12	5	5	None	2.3x10 ⁻³	2.3x10 ⁻³	0.44	0.019	0.09	0.019	0.09	0	0	0
1,1,1-Trichloroethane (TCA)	1	1,900	1,900	None	4.6x10 ⁻⁴	4.6x10 ⁻⁴	8.7x10 ⁻²	4.6x10 ⁻⁴	4.6x10 ⁻⁵	4.6x10 ⁻⁴	4.6x10 ⁻⁵	0	0	0
Hazard Index^f								0.02	0.09	0.02	0.09	0	0	0
Total Cancer Risk^g														

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual Hazard Quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; ORR 1993a;8; FDI Nov. 4, 1994 Log # FO-94-0354.

TABLE E.3.4-19.—Risk Assessments from Exposure to Hazardous Chemicals from Accelerator Production of Tritium Operation at Oak Ridge Reservation

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory			Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg-kg/day)	Boundary		Worker 100 Meters 8 Hours	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c Annual	Boundary MEI ^{a,d} 100 Meters 8 Hours ^e
					MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)				
Acetylene	66.28	2,708	2,708	None	1.1x10 ⁻⁴	0.02	1.6x10 ⁻⁶	7.4x10 ⁻⁶	0	0
Ethanol	46.1	1,900	1,880	None	3.9x10 ⁻⁵	7.5x10 ⁻³	8.5x10 ⁻⁷	4.0x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	1.1x10 ⁻⁴	0.02	0	0	0	0
Methanol	1.75	260	200	None	3.9x10 ⁻⁵	7.5x10 ⁻³	2.2x10 ⁻⁵	2.9x10 ⁻⁵	0	0
Hazard Index ^f							2.5x10 ⁻⁵	4.0x10 ⁻⁵		
Total Cancer Risk ^g									0	0

^a MEI: maximally exposed individual of the public.

^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.

^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permisible exposure limit.

^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).

^f Hazard Index: sum of individual Hazard Quotients.

^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; ORR 1993a:8.

TABLE E.3.4-20.—Risk Assessments from Exposure to Hazardous Chemicals from Tritium Recycling Operation at Oak Ridge Reservation

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary		Boundary		Worker 100 Meters Annual
					MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	
Acetylene	66.28	2,708	2,708	None	1.1x10 ⁻⁴	0.02	1.6x10 ⁻⁶	7.4x10 ⁻⁶	0
Ethanol	46.1	1,900	1,880	None	3.9x10 ⁻⁵	7.5x10 ⁻³	8.5x10 ⁻⁷	4.0x10 ⁻⁶	0
Methane (simple asphyxiant)	None	None	None	None	1.1x10 ⁻⁴	0.02	0	0	0
Methanol	1.75	260	200	None	3.9x10 ⁻⁵	7.5x10 ⁻³	2.2x10 ⁻⁵	2.9x10 ⁻⁵	0
Hazard Index^f							2.5x10⁻⁵	4.0x10⁻⁵	
Total Cancer Risk^g									0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/reference concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual Hazard Quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; ORR 1993a:8.

TABLE E.3.4-21.—Risk Assessments from Exposure to Hazardous Chemicals at Oak Ridge Reservation—Summary Hazard Index and Total Cancer Risk

Technology ^a	Hazard Index		Total Cancer Risk	
	Boundary MEI ^{b,c} Annual	Worker 100 Meters 8 Hours ^b	Boundary MEI ^{d,e} Annual	Worker 100 Meters 8 Hours ^{d,f}
No Action	0.36	0.26	0	0
Tritium Recycle	2.5x10 ⁻⁵	4.0x10 ⁻⁵	0	0
Heavy Water Reactor	1.7x10 ⁻³	7.7x10 ⁻³	0	0
Heavy Water Reactor and Tritium Recycling	1.7x10 ⁻³	7.7x10 ⁻³	0	0
Heavy Water Reactor, Tritium Recycling and No Action	0.36	0.27	0	0
Modular High Temperature Gas-Cooled Reactor	3.0x10 ⁻⁴	0.06	0	0
Modular High Temperature Gas-Cooled Reactor and Tritium Recycling	3.2x10 ⁻⁴	0.06	0	0
Modular High Temperature Gas-Cooled Reactor, Tritium Recycling and No Action	0.36	0.32	0	0
Advanced Light Water Reactor	0.021	0.090	0	0
Advanced Light Water Reactor and Tritium Recycling	0.022	0.090	0	0
Advanced Light Water Reactor, Tritium Recycling and No Action	0.38	0.35	0	0
Accelerated Production of Tritium	2.5x10 ⁻⁵	4.0x10 ⁻⁵	0	0
Accelerated Production of Tritium and Tritium Recycling	5.0x10 ⁻⁵	8.1x10 ⁻⁵	0	0
Accelerated Production of Tritium, Tritium Recycling and No Action	0.36	0.26	0	0

^a Combined Hazard Index and total cancer risk for these alternatives.

^b MEI: maximally exposed individual of the public.

^c Hazard Index: sum of individual Hazard Quotient.

^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Total Cancer Risk: sum of individual cancer risks.

^f Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (slope factor).

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; ORR 1993a;8; PX 1992a;10.

TABLE E.3.4-22.—Risk Assessments from Exposure to Hazardous Chemicals from No Action Operation at Pantex Plant [Page 1 of 3]

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	Boundary Annual MEI ^{a,b}	Worker 100 Meters 8 Hours	Boundary Annual MEI ^{a,d}	Worker 100 Meters 8 Hours
Acetone	10.5	1,800.0	1,800.0	None	2.0x10 ⁻⁴	0.39	1.9x10 ⁻⁵	2.2x10 ⁻⁴	0	0
Aliphatic alcohols (n-butyl alcohol)	0.35	150.0		None	7.6x10 ⁻⁸	5.5x10 ⁻⁴	2.2x10 ⁻⁷	3.7x10 ⁻⁶	0	0
Aliphatic hydrocarbons (cyclohexane)	25.7	1,050.0	1,050.0	None	3.2x10 ⁻⁶	0.02	1.2x10 ⁻⁷	2.0x10 ⁻⁵	0	0
2-butoxyethanol	2.96	240.0		None	1.3x10 ⁻⁴	0.24	4.4x10 ⁻⁵	9.9x10 ⁻⁴	0	0
Butyl acetate	17.4	710.0	710.0	None	1.4x10 ⁻⁵	0.10	8.0x10 ⁻⁷	1.4x10 ⁻⁴	0	0
Butyl alcohol	0.35	150.0	152.0	None	5.2x10 ⁻⁶	0.04	1.5x10 ⁻⁵	2.4x10 ⁻⁴	0	0
Chlorodifluoromethane (Freon 142)	86.7	3,540.0		None	3.0x10 ⁻⁶	5.5x10 ⁻³	3.5x10 ⁻⁸	1.6x10 ⁻⁶	0	0
Cyanogen	0.245	20.0		None	7.6x10 ⁻⁶	0.18	3.1x10 ⁻⁵	9.2x10 ⁻³	0	0
Cyclohexane	25.7	1,050.0	1,050.0	None	1.8x10 ⁻⁶	3.3x10 ⁻³	7.1x10 ⁻⁸	3.2x10 ⁻⁶	0	0
Diacetone alcohol	5.88	240.0		None	1.5x10 ⁻⁷	1.1x10 ⁻³	2.6x10 ⁻⁸	4.6x10 ⁻⁶	0	0
Dibutyl phthalate	0.35	5.0	5.0	None	2.3x10 ⁻⁷	1.7x10 ⁻³	6.5x10 ⁻⁷	3.3x10 ⁻⁴	0	0
Dichlorodifluoromethane (Freon 12)	0.7	4,950.0	4,950.0	None	4.3x10 ⁻⁶	0.03	6.2x10 ⁻⁶	5.4x10 ⁻⁶	0	0
Diesel (undefined complex)				None	1.5x10 ⁻⁶	2.8x10 ⁻³	0	0	0	0
Diethylene glycol ethyl ether	0.35	50.0		None	7.6x10 ⁻⁸	5.5x10 ⁻⁴	2.2x10 ⁻⁷	1.1x10 ⁻⁵	0	0
Epoxy solvent (toluene)	0.4	375.0		None	2.6x10 ⁻⁶	0.02	6.5x10 ⁻⁶	5.0x10 ⁻⁵	0	0
Ethanol	46.1	1,900.0	1,880.0	None	3.5x10 ⁻⁶	0.01	7.6x10 ⁻⁸	7.3x10 ⁻⁶	0	0
Ethyl acetate	3.15	1,400.0	1,400.0	None	9.9x10 ⁻⁷	7.2x10 ⁻³	3.1x10 ⁻⁷	5.1x10 ⁻⁶	0	0
Ethyl benzene	1.0	435.0		None	1.5x10 ⁻⁷	1.1x10 ⁻³	1.5x10 ⁻⁷	2.5x10 ⁻⁶	0	0
Freon TF (Freon 11)	1.05	5,600.0	5,620.0	None	1.6x10 ⁻⁵	0.03	1.5x10 ⁻⁵	5.0x10 ⁻⁶	0	0
Heptane	40.1	2,000.0	1,640.0	None	3.8x10 ⁻⁷	2.8x10 ⁻³	9.5x10 ⁻⁹	1.4x10 ⁻⁶	0	0
Hydrocarbons (heptane)	40.1	2,000.0		None	8.0x10 ⁻⁵	2.06	2.0x10 ⁻⁶	1.0x10 ⁻³	0	0
Hydrogen chloride	0.007	7.0	7.0	None	1.1x10 ⁻⁵	0.26	1.6x10 ⁻³	0.04	0	0
Hydrogen cyanide	0.07	5.0		None	1.1x10 ⁻⁶	0.03	1.5x10 ⁻⁵	5.1x10 ⁻³	0	0
Hydrogen fluoride	0.063	2.5	2.6	None	1.3x10 ⁻⁵	0.33	2.1x10 ⁻⁴	0.13	0	0

TABLE E.3.4-22.—Risk Assessments from Exposure to Hazardous Chemicals from No Action Operation at Pantex Plant [Page 2 of 3]

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory			Hazard Quotient			Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary		Worker 100 Meters 8 Hours (mg/m ³)	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e	
					MEI ^a Annual (mg/m ³)	Annual (mg/m ³)						
Isopropyl alcohol	24.15	980.0	980.0	None	2.2x10 ⁻⁵	0.14	8.9x10 ⁻⁷	1.5x10 ⁻⁴	0	0	0	
Isobutane	35.04	1,430.0		None	2.3x10 ⁻⁷	1.7x10 ⁻³	6.5x10 ⁻⁹	1.2x10 ⁻⁶	0	0	0	
Isobutyl acetate	17.15	700.0		None	3.8x10 ⁻⁷	2.8x10 ⁻³	2.2x10 ⁻⁸	3.9x10 ⁻⁶	0	0	0	
Methanol	1.75	260.0	200.0	None	1.1x10 ⁻⁴	0.20	6.3x10 ⁻⁵	7.8x10 ⁻⁴	0	0	0	
Methyl ethyl ketone	1.00	590.0	590.0	None	1.5x10 ⁻⁵	0.11	1.5x10 ⁻⁵	1.8x10 ⁻⁴	0	0	0	
Methyl isobutyl ketone	0.05	205.0	205.0	None	1.7x10 ⁻⁶	6.1x10 ⁻³	3.5x10 ⁻⁵	3.0x10 ⁻⁵	0	0	0	
Methylene chloride	3.00	1,765.0		0.0075	7.6x10 ⁻⁷	2.2x10 ⁻³	2.5x10 ⁻⁷	1.2x10 ⁻⁶	1.6x10 ⁻⁹	6.4x10 ⁻⁷	0	
Nitrocellulose	0.7	100.0		None	5.3x10 ⁻⁷	3.9x10 ⁻³	7.6x10 ⁻⁷	3.9x10 ⁻⁵	0	0	0	
Perfluoroalkylether (isoflurane)	17.76	2,537.143		None	7.6x10 ⁻⁸	5.5x10 ⁻⁴	4.3x10 ⁻⁹	2.2x10 ⁻⁷	0	0	0	
Perfluoro compounds (Freon 114)	171.3	7,000.0		None	3.0x10 ⁻⁷	5.5x10 ⁻⁴	1.8x10 ⁻⁹	7.9x10 ⁻⁸	0	0	0	
Propane	44.1	1,800.0		None	6.8x10 ⁻⁷	5.0x10 ⁻³	1.6x10 ⁻⁸	2.8x10 ⁻⁶	0	0	0	
Propyl glycol methyl ether (propylene glycol monomethyl ether)	9.04	369.0		None	3.0x10 ⁻⁷	2.2x10 ⁻³	3.4x10 ⁻⁸	6.0x10 ⁻⁶	0	0	0	
Resins and formers (toluene-2,4 diisocyanate)	0.001	0.14		None	1.3x10 ⁻⁶	9.4x10 ⁻³	1.3x10 ⁻³	0.07	0	0	0	
Methyl tert butyl ether	0.5	71.429		None	5.1x10 ⁻⁶	2.2x10 ⁻³	1.0x10 ⁻⁵	3.1x10 ⁻⁵	0	0	0	
Tetrahydrofuran	14.46	590.0		None	1.9x10 ⁻⁵	0.03	1.3x10 ⁻⁶	5.7x10 ⁻⁵	0	0	0	
Toluene	0.4	375.0	383.0	None	1.3x10 ⁻⁴	0.27	3.2x10 ⁻⁴	7.1x10 ⁻⁴	0	0	0	
1,1,1 Trichloroethane (TCA)	1.0	1,900.0	1,900.0	None	2.2x10 ⁻⁶	9.4x10 ⁻³	2.2x10 ⁻⁶	4.9x10 ⁻⁶	0	0	0	
Trichloroethylene	0.046	270.0		0.006	7.9x10 ⁻⁸	5.5x10 ⁻⁴	1.7x10 ⁻⁶	2.0x10 ⁻⁶	1.4x10 ⁻¹⁰	1.3x10 ⁻⁷	0	
Trichlorofluoromethane (Freon 11)	1.05	5,600.0	5,620.0	None	4.6x10 ⁻⁷	1.7x10 ⁻³	4.3x10 ⁻⁷	2.9x10 ⁻⁷	0	0	0	
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	105.0	7,600.0	7,600.0	None	3.3x10 ⁻⁶	0.01	3.2x10 ⁻⁸	1.9x10 ⁻⁶	0	0	0	

TABLE E.3.4-22.—Risk Assessments from Exposure to Hazardous Chemicals from No Action Operation at Pantex Plant [Page 3 of 3]

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory			Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg-kg/day)	Boundary MEI ^a		Worker 100 Meters Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
					Annual (mg/m ³)	8 Hours (mg/m ³)				
Trichlorotrifluoroethane (Freon 113)	105.0	7,600.0	7,600.0	None	4.1x10 ⁻⁶	8.3x10 ⁻³	3.9x10 ⁻⁸	1.1x10 ⁻⁶	0	0
VM and P naphtha	29.4	400.0		None	3.9x10 ⁻⁶	0.03	1.3x10 ⁻⁷	6.6x10 ⁻⁵	0	0
Xylene	7.0	435.0		None	2.7x10 ⁻⁶	0.05	3.9x10 ⁻⁷	1.2x10 ⁻⁴		
Hazard Index^f							3.7x10⁻³	2.6x10⁻¹		
Total Cancer Risk^g									1.3x10⁻⁹	7.7x10⁻⁷

^a MEI: maximally exposed individual of the public.

^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.

^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permisible exposure limit.

^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).

^f Hazard Index: sum of individual hazard quotients.

^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; PX 1992a:10.

TABLE E.3.4-23.—Risk Assessments from Exposure to Hazardous Chemicals from Heavy Water Reactor Operation at Pantex Plant

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg·kg/day)	Boundary MEI ^a		Boundary MEI ^{a,b}		Boundary MEI ^{a,d}	
					Annual (mg/m ³)	100 Meters 8 Hours (mg/m ³)	Annual	100 Meters 8 Hours ^c	Annual	100 Meters 8 Hours ^e
Acetylene	66.28	2,708	2,708	None	1.9x10 ⁻³	8.1x10 ⁻³	2.8x10 ⁻⁵	3.0x10 ⁻⁶	0	0
Ethanol	46.10	1,900	1,880	None	6.9x10 ⁻⁶	3.0x10 ⁻³	1.5x10 ⁻⁷	1.6x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	1.9x10 ⁻³	8.1x10 ⁻³	0	0	0	0
Methanol	1.75	260	200	None	6.9x10 ⁻⁶	3.0x10 ⁻³	4.0x10 ⁻⁶	1.2x10 ⁻⁵	0	0
Nitric acid	0.123	5	5	None	3.5x10 ⁻⁵	0.02	2.8x10 ⁻⁴	3.0x10 ⁻³	0	0
1,1,1-Trichloroethane (TCA)	1.0	1,900	1,900	None	5.8x10 ⁻⁶	2.5x10 ⁻³	5.8x10 ⁻⁶	1.3x10 ⁻⁶	0	0
Trichlorotrifluoroethane (Freon 113)	105.0	7,600	7,600	None	2.5x10 ⁻⁴	0.11	2.4x10 ⁻⁶	1.4x10 ⁻⁵	0	0
Hazard Index ^f							3.2x10 ⁻⁴	3.1x10 ⁻³		
Total Cancer Risk ^g									0	0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual hazard quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; PX 1992a:10.

TABLE E.3.4-24.—Risk Assessments from Exposure to Hazardous Chemicals from Modular High Temperature Gas-Cooled Reactor Operation at Pantex Plant

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Value (mg/m ³)	Slope Factor (mg-kg/day)	Boundary MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual
Acetylene	66.28	2,708	2,708	None	1.7x10 ⁻⁵	7.3x10 ⁻³	2.5x10 ⁻⁷	2.7x10 ⁻⁶	0
Ethanol	46.10	1,900	1,880	None	6.2x10 ⁻⁶	2.7x10 ⁻³	1.3x10 ⁻⁷	1.4x10 ⁻⁶	0
Methane (simple asphyxiant)	None	None	None	None	1.7x10 ⁻⁵	7.3x10 ⁻³	0	0	0
Methanol	1.75	260	200	None	6.2x10 ⁻⁶	2.7x10 ⁻³	3.5x10 ⁻⁶	1.0x10 ⁻⁵	0
1,1,1-Trichloroethane (TCA)	1.00	1,900	1,900	None	1.9x10 ⁻⁶	8.2x10 ⁻⁴	1.9x10 ⁻⁶	4.3x10 ⁻⁷	0
Hazard Index^f							5.8x10⁻⁶	1.5x10⁻⁵	
Total Cancer Risk^g									0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentration) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual hazard quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; PX 1992a:10.

TABLE E.3.4-25.—Risk Assessments from Exposure to Hazardous Chemicals from Advanced Light Water Reactor Operation at Pantex Plant

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary MEI ^a		Boundary MEI ^{a,b}		Boundary MEI ^{a,d}	
					Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	Annual	Worker 100 Meters 8 Hours	Annual	Worker 100 Meters 8 Hours
Acetone	10.5	1,800	1,800	None	5.8x10 ⁻⁵	0.03	5.6x10 ⁻⁶	1.4x10 ⁻⁵	0	0
Acetylene	66.28	2,708	2,708	None	1.9x10 ⁻⁵	8.1x10 ⁻³	2.8x10 ⁻⁷	3.0x10 ⁻⁶	0	0
Ammonia	0.1	27	17	None	3.1x10 ⁻⁵	0.01	3.1x10 ⁻⁴	4.9x10 ⁻⁴	0	0
Ethanol	46.1	1,900	1,880	None	6.9x10 ⁻⁶	3.0x10 ⁻³	1.5x10 ⁻⁷	1.6x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	1.9x10 ⁻⁵	8.1x10 ⁻³	0	0	0	0
Methanol	1.75	260	200	None	6.9x10 ⁻⁶	3.0x10 ⁻³	4.0x10 ⁻⁶	1.2x10 ⁻⁵	0	0
Nitric acid	0.123	5	5	None	4.1x10 ⁻⁴	0.02	3.3x10 ⁻³	3.5x10 ⁻³	0	0
1,1,1-Trichloroethane (TCA)	1.0	1,900	1,900	None	8.0x10 ⁻⁵	3.5x10 ⁻²	8.0x10 ⁻⁵	1.8x10 ⁻⁵	0	0
Hazard Index^f							3.7x10⁻³	4.1x10⁻³		
Total Cancer Risk^g									0	0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/reference concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual hazard quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; PX 1992a:10.

TABLE E.3.4-26.—Risk Assessments from Exposure to Hazardous Chemicals from Accelerator Production of Tritium Operation at Pantex Plant

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg-kg/day)	Boundary MEI ^a		Boundary MEI ^{a,b}		Worker 100 Meters 8 Hours ^c	
					Annual (mg/m ³)	8 Hours (mg/m ³)	Annual	MEI ^{a,b}	Annual	Worker 100 Meters 8 Hours ^c
Acetylene	66.28	2,708	2,708	None	1.9x10 ⁻³	8.1x10 ⁻³	2.8x10 ⁻⁵	3.0x10 ⁻⁶	0	0
Ethanol	46.10	1,900	1,880	None	6.9x10 ⁻⁶	3.0x10 ⁻³	1.5x10 ⁻⁷	1.6x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	1.9x10 ⁻³	8.1x10 ⁻³	0	0	0	0
Methanol	1.75	260	200	None	6.9x10 ⁻⁶	3.0x10 ⁻³	4.0x10 ⁻⁶	1.2x10 ⁻⁵	0	0
Hazard Index^f							3.2x10⁻⁵	1.6x10⁻⁵	0	0
Total Cancer Risk^g										

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permmissible exposure limit.^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual hazard quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; PX 1992a:10.

TABLE E.3.4-27.—Risk Assessments from Exposure to Hazardous Chemicals from Tritium Recycling Operation at Pantex Plant

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory			Hazard Quotient			Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary MEI ^a		Worker 100 Meters 8 Hours (mg/m ³)	Boundary MEI ^{a,b}		Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
					Annual (mg/m ³)	Annual (mg/m ³)		Annual (mg/m ³)	Annual (mg/m ³)			
Acetylene	66.28	2,708	2,708	None	1.9x10 ⁻³	8.1x10 ⁻³	8.1x10 ⁻³	2.8x10 ⁻⁵	3.0x10 ⁻⁶	0	0	0
Ethanol	46.10	1,900	1,880	None	6.9x10 ⁻⁶	3.0x10 ⁻³	3.0x10 ⁻³	1.5x10 ⁻⁷	1.6x10 ⁻⁶	0	0	0
Methane (simple asphyxiant)	None	None	None	None	1.9x10 ⁻³	8.1x10 ⁻³	8.1x10 ⁻³	0	0	0	0	0
Methanol	1.75	260	200	None	6.9x10 ⁻⁶	3.0x10 ⁻³	3.0x10 ⁻³	4.0x10 ⁻⁶	1.2x10 ⁻⁵	0	0	0
Hazard Index^f												
Total Cancer Risk^g								3.2x10⁻⁵	1.6x10⁻⁵		0	0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual hazard quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; FDI 1994h; SNL 1995a; PX 1992a:10.

TABLE E.3.4-28.---Risk Assessments from Exposure to Hazardous Chemicals at Pantex Plant--Summary Hazard Index and Total Cancer Risk

Technology ^a	Hazard Index		Total Cancer Risk	
	Boundary MEI ^{b,c} Annual	Worker 100 Meters 8 Hours ^b	Boundary MEI ^{d,e} Annual	Worker 100 Meters 8 Hours ^{d,f}
No Action	3.7x10 ⁻³	0.26	1.8x10 ⁻⁹	7.7x10 ⁻⁷
Tritium Recycle	3.2x10 ⁻⁵	1.6x10 ⁻⁵	0	0
Heavy Water Reactor	3.2x10 ⁻⁴	3.1x10 ⁻³	0	0
Heavy Water Reactor and Tritium Recycling	3.6x10 ⁻⁴	3.1x10 ⁻³	0	0
Heavy Water Reactor, Tritium Recycling, and No Action	4.1x10 ⁻³	0.26	1.8x10 ⁻⁹	7.7x10 ⁻⁷
Modular High Temperature Gas-Cooled Reactor	5.8x10 ⁻⁶	1.5x10 ⁻⁵	0	0
Modular High Temperature Gas-Cooled Reactor and Tritium Recycling	3.8x10 ⁻⁵	3.1x10 ⁻⁵	0	0
Modular High Temperature Gas-Cooled Reactor, Tritium Recycling, and No Action	3.7x10 ⁻³	0.26	1.8x10 ⁻⁹	7.7x10 ⁻⁷
Advanced Light Water Reactor	3.7x10 ⁻³	4.1x10 ⁻³	0	0
Advanced Light Water Reactor and Tritium Recycling	3.8x10 ⁻³	4.1x10 ⁻³	0	0
Advanced Light Water Reactor, Tritium Recycling, and No Action	7.5x10 ⁻³	0.26	1.8x10 ⁻⁹	7.7x10 ⁻⁷
Accelerated Production of Tritium	3.2x10 ⁻⁵	1.6x10 ⁻⁵	0	0
Accelerated Production of Tritium and Tritium Recycling	6.4x10 ⁻⁵	3.2x10 ⁻⁵	0	0
Accelerated Production of Tritium, Tritium Recycling and No Action	3.8x10 ⁻³	0.26	1.8x10 ⁻⁹	7.7x10 ⁻⁷

^a Combined Hazard Index and total cancer risk for these alternatives.

^b MEI: maximally exposed individual of the public.

^c Hazard Index: sum of individual Hazard Quotient.

^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Total Cancer Risk: sum of individual cancer risks.

^f Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (slope factor).

Source: Calculated from model data derived from DOE 1995d; DOE 1995e; DOE 1995f; DOE 1995g; SNL 1995a; FDI 1994h; PX 1992a:10.

TABLE E.3.4-29.—Risk Assessments from Exposure to Hazardous Chemicals from No Action Operation at Savannah River Site [Page 1 of 2]

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory				Hazard Quotient				Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary		Worker 100 Meters 8 Hours (mg/m ³)	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours	Boundary Annual	Worker 100 Meters 8 Hours	
					Annual (mg/m ³)	Annual (mg/m ³)								
Acrolein	0.0002	0.25	0.23	None	1.6x10 ⁻⁶	2.1x10 ⁻³	0.08	0.01	0	0	0	0	0	0
Acrylonitrile	0.002	4.42	4.3	0.24	1.6x10 ⁻⁶	2.1x10 ⁻³	7.8x10 ⁻⁴	4.8x10 ⁻⁴	1.1x10 ⁻⁷	2.0x10 ⁻⁵	0	0	0	0
Antimony	0.0000139	0.5	0.5	None	9.2x10 ⁻⁷	1.2x10 ⁻³	0.07	2.5x10 ⁻³	0	0	0	0	0	0
Benzene	0.783	3.25	32.0	0.029	2.3x10 ⁻³	3.1	2.9x10 ⁻³	0.95	1.9x10 ⁻⁵	3.5x10 ⁻³	0	0	0	0
Cadmium	0.0005	0.2	0.05	None	9.2x10 ⁻⁷	1.3x10 ⁻³	1.8x10 ⁻³	6.3x10 ⁻³	0	0	0	0	0	0
Cadmium oxide	0.0025	0.1	0.05	None	1.1x10 ⁻⁶	1.4x10 ⁻³	4.2x10 ⁻⁴	0.014	0	0	0	0	0	0
Chlorine	0.039	1.5	1.0	None	1.2x10 ⁻⁴	0.16	3.1x10 ⁻³	0.11	0	0	0	0	0	0
2,4-Dinitrotoluene	0.0069	1.5	0.15	None	1.8x10 ⁻⁵	0.03	2.7x10 ⁻³	0.02	0	0	0	0	0	0
Diethyl phthalate	0.07	5.0	5.0	0.014	2.1x10 ⁻⁶	2.9x10 ⁻³	3.1x10 ⁻⁵	5.8x10 ⁻⁴	8.6x10 ⁻⁹	1.6x10 ⁻⁶	0	0	0	0
Ethyl benzene	1.0	435.0	434.0	None	2.1x10 ⁻⁵	0.03	2.1x10 ⁻⁵	6.7x10 ⁻⁵	0	0	0	0	0	0
Ethylene glycol	0.2	740.0	18.0	None	8.1x10 ⁻⁶	0.01	4.1x10 ⁻⁵	1.5x10 ⁻⁵	0	0	0	0	0	0
Formic acid	6.994	9.0	9.4	None	2.9x10 ⁻⁵	0.04	4.2x10 ⁻⁶	4.4x10 ⁻³	0	0	0	0	0	0
Hexane	0.2	1,800.0	176.0	None	4.1x10 ⁻⁶	5.5x10 ⁻³	2.0x10 ⁻⁵	3.1x10 ⁻⁶	0	0	0	0	0	0
Hydrogen chloride	0.007	7.0	7.0	None	2.9x10 ⁻³	3.9	0.41	0.55	0	0	0	0	0	0
Hydrogen sulfide	0.0009	14.0	14.0	None	8.3x10 ⁻⁵	0.11	0.09	8.1x10 ⁻³	0	0	0	0	0	0
Manganese	0.005	1.0	2.0	None	6.3x10 ⁻⁶	8.5x10 ⁻³	1.3x10 ⁻³	8.5x10 ⁻³	0	0	0	0	0	0
Mercury	0.0003	0.05	0.05	None	3.2x10 ⁻⁶	4.3x10 ⁻³	0.01	0.09	0	0	0	0	0	0
Methanol	1.75	260.0	200.0	None	6.4x10 ⁻⁶	8.6x10 ⁻³	3.6x10 ⁻⁶	3.3x10 ⁻⁵	0	0	0	0	0	0
Methylene chloride	3.0	1,765.0	177.0	0.0075	2.2x10 ⁻⁵	0.03	7.3x10 ⁻⁶	1.7x10 ⁻⁵	4.7x10 ⁻⁸	8.6x10 ⁻⁶	0	0	0	0
Methyl ethyl ketone (MEK)	1.0	590.0	590.0	None	8.1x10 ⁻⁵	0.11	8.1x10 ⁻⁵	1.9x10 ⁻⁴	0	0	0	0	0	0
Methyl tert-butyl ether	0.2	20.0		None	3.1x10 ⁻⁵	0.04	1.6x10 ⁻⁴	2.1x10 ⁻³	0	0	0	0	0	0
Methyl isobutyl ketone (MIK)	0.05	205.0	205.0	None	4.2x10 ⁻⁵	0.06	8.4x10 ⁻⁴	2.8x10 ⁻⁴	0	0	0	0	0	0
Nickel	0.02	1.0	1.0	0.84	4.3x10 ⁻⁶	5.8x10 ⁻³	2.2x10 ⁻⁴	5.8x10 ⁻³	1.0x10 ⁻⁶	1.9x10 ⁻⁴	0	0	0	0
Nickel oxide	0.0012	0.1	0.1	None	9.2x10 ⁻⁷	1.2x10 ⁻³	7.7x10 ⁻⁴	0.01	0	0	0	0	0	0
Nitric acid	0.123	5.0	5.0	None	4.8x10 ⁻⁵	0.06	3.9x10 ⁻⁴	0.01	0	0	0	0	0	0
Sodium hydroxide	0.0489	2.0	2.0	None	6.3x10 ⁻⁶	8.6x10 ⁻³	1.3x10 ⁻⁴	4.3x10 ⁻³	0	0	0	0	0	0
Sulfuric acid	0.0245	1.0	1.0	None	9.5x10 ⁻⁷	1.3x10 ⁻³	3.9x10 ⁻⁵	1.3x10 ⁻³	0	0	0	0	0	0

TABLE E.3.4-29.—Risk Assessments from Exposure to Hazardous Chemicals from No Action Operation at Savannah River Site [Page 2 of 2]

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory			Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold		Slope Factor (mg/kg/day)	Boundary		Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual
			Limit Value (mg/m ³)	Limit (mg/m ³)		Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)				Worker 100 Meters 8 Hours ^e
Tetrachloroethylene (PERC)	0.03496503	170.0	339.0	None	5.3x10 ⁻⁴	0.72	1.5x10 ⁻²	4.2x10 ⁻³	0	0	0
Toluene	0.4	375.0	377.0	None	2.8x10 ⁻⁵	0.04	7.1x10 ⁻⁵	1.0x10 ⁻⁴	0	0	0
1,1,1-Trichloroethane (111-TCA)	1.0	1,900.0	1,900.0	None	2.2x10 ⁻⁵	0.03	2.2x10 ⁻⁵	1.6x10 ⁻⁵	0	0	0
Trichloroethylene (TCE)	0.046	270.0	270.0	0.006	1.8x10 ⁻⁴	0.24	3.9x10 ⁻³	9.0x10 ⁻⁴	3.1x10 ⁻⁷	5.6x10 ⁻⁵	2.2x10 ⁻³
Trichloromethane (chloroform)	0.03497	240.0	9.78	0.081	5.2x10 ⁻⁴	0.70	1.5x10 ⁻²	2.9x10 ⁻³	1.2x10 ⁻⁵	2.2x10 ⁻³	2.2x10 ⁻³
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	105.0	7,600.0	7,670.0	None	1.6x10 ⁻⁶	2.1x10 ⁻³	1.5x10 ⁻⁸	2.8x10 ⁻⁷	0	0	0
Xylene	7.0	435.0	435.0	None	3.8x10 ⁻⁴	0.51	5.4x10 ⁻⁵	1.2x10 ⁻³	0	0	0
Hazard Index ^f							0.70	1.8			
Total Cancer Risk ^g									3.2x10 ⁻⁵		5.9x10 ⁻³

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.571 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual hazard quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; SR DOE 1995a; SRS 1993a.3.

TABLE E.3.4-30.—Risk Assessments from Exposure to Hazardous Chemicals from Heavy Water Reactor Operation at Savannah River Site

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory			Hazard Quotient			Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary		Boundary Annual	Worker 100 Meters 8 Hours ^c	Boundary Annual	Worker 100 Meters 8 Hours ^c	Cancer Risk
					MEI ^a	Annual					
Acetylene	66.28	2,708	2,708	None	1.1x10 ⁻⁵	0.01	1.6x10 ⁻⁷	5.3x10 ⁻⁶	0	0	0
Ethanol	46.1	1,900	1,900	None	3.9x10 ⁻⁶	5.3x10 ⁻³	8.5x10 ⁻⁸	2.8x10 ⁻⁶	0	0	0
Methane (simple asphyxiant)	None	None	None	None	1.1x10 ⁻⁵	0.01	0	0	0	0	0
Methanol	1.75	260	260	None	3.9x10 ⁻⁶	5.3x10 ⁻³	2.2x10 ⁻⁶	2.0x10 ⁻⁵	0	0	0
1,1,1-Trichloroethane (TCA)	1.0	1,900	1,900	None	1.2x10 ⁻⁶	1.6x10 ⁻³	1.2x10 ⁻⁶	8.5x10 ⁻⁷	0	0	0
Hazard Index^f							3.7x10 ⁻⁶	2.9x10 ⁻⁵	0	0	0
Total Cancer Risk^g									0	0	0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permmissible exposure limit.^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual hazard quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; SR DOE 1995a; SRS 1993a:3.

TABLE E.3.4-31.—Risk Assessments from Exposure to Hazardous Chemicals from Modular High Temperature Gas-Cooled Reactor Operation at Savannah River Site

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual
Acetylene	66.28	2,708	2,708	None	4.0x10 ⁻⁶	6.0x10 ⁻⁵	6.1x10 ⁻⁸	2.2x10 ⁻⁸	0
Ammonia	0.01	27	17	None	1.1x10 ⁻⁶	1.6x10 ⁻⁵	1.1x10 ⁻⁴	6.1x10 ⁻⁷	0
Ethanol	46.1	1,900	1,900	None	3.3x10 ⁻⁵	4.8x10 ⁻⁴	7.3x10 ⁻⁷	2.5x10 ⁻⁷	0
Methanol	1.75	260	260	None	3.3x10 ⁻⁵	4.8x10 ⁻⁴	1.9x10 ⁻⁵	1.8x10 ⁻⁶	0
1,1,1-Trichloroethane (TCA)	1.0	1,900	1,900	None	1.4x10 ⁻⁶	2.1x10 ⁻⁵	1.4x10 ⁻⁶	1.1x10 ⁻⁸	0
Trichlorotrifluoroethane (Freon 113)	105.0	7,600	7,670	None	1.5x10 ⁻⁴	2.3x10 ⁻³	1.4x10 ⁻⁶	3.0x10 ⁻⁷	0
Hazard Index^f							1.3x10 ⁻⁴	3.0x10 ⁻⁶	
Total Cancer Risk^g									0

^a MEI: maximally exposed individual of the public.

^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.

^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.

^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).

^f Hazard Index: sum of individual hazard quotients.

^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; SR DOE 1995a; SRS 1993a.3.

TABLE E.3.4-32.—Risk Assessments from Exposure to Hazardous Chemicals from Advanced Light Water Reactor at Savannah River Site

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary MEI ^a		Worker MEI ^{a,b}		Boundary MEI ^{a,d}	
					Annual (mg/m ³)	8 Hours (mg/m ³)	Annual (mg/m ³)	8 Hours ^c	Annual	8 Hours ^e
Acetone	10.5	1,800	1,800	None	3.7x10 ⁻⁵	0.05	3.5x10 ⁻⁶	2.8x10 ⁻⁵	0	0
Acetylene	66.28	2,708	2,708	None	1.1x10 ⁻⁵	0.01	1.6x10 ⁻⁷	5.3x10 ⁻⁶	0	0
Ammonia	0.01	27	17	None	1.9x10 ⁻⁵	0.03	1.9x10 ⁻³	9.7x10 ⁻⁴	0	0
Ethanol	46.1	1,900	1,900	None	3.9x10 ⁻⁶	5.3x10 ⁻³	8.5x10 ⁻⁸	2.8x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	1.1x10 ⁻⁵	0.01	0	0	0	0
Methanol	1.75	260	260	None	3.9x10 ⁻⁶	5.3x10 ⁻³	2.2x10 ⁻⁶	2.0x10 ⁻⁵	0	0
Nitric acid	0.123	5	5	None	2.6x10 ⁻⁴	0.35	2.1x10 ⁻³	0.07	0	0
1,1,1-Trichloroethane (TCA)	1.0	1,900	1,900	None	8.5x10 ⁻⁵	0.11	8.5x10 ⁻⁵	6.0x10 ⁻⁵	0	0
Hazard Index^f							4.1x10⁻³	0.071	0	0
Total Cancer Risk^g										

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual hazard quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994b; SNL 1995a; SR DOE 1995a; SRS 1993a:3.

TABLE E.3.4-33.—Risk Assessments from Exposure to Hazardous Chemicals from Accelerator Production of Tritium Operation at Savannah River Site

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	Boundary MEI ^{a,d} Annual
Acetylene	66.28	2,708	2,708	None	1.1x10 ⁻⁵	0.01	1.6x10 ⁻⁷	5.3x10 ⁻⁶	0
Ethanol	46.1	1,900	1,900	None	3.9x10 ⁻⁶	5.3x10 ⁻³	8.5x10 ⁻⁸	2.8x10 ⁻⁶	0
Methane (simple asphyxiant)	None	None	None	None	1.1x10 ⁻⁵	0.01	0	0	0
Methanol	1.75	260	260	None	3.9x10 ⁻⁶	5.3x10 ⁻³	2.2x10 ⁻⁶	2.0x10 ⁻⁵	0
Hazard Index^f							2.5x10 ⁻⁶	2.8x10 ⁻⁵	
Total Cancer Risks^g									0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual hazard quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; SR DOE 1995a; SRS 1993a.3.

TABLE E.3.4-34.—Risk Assessments from Exposure to Hazardous Chemicals from Tritium Recycling Upgrade Operation at Savannah River Site

Chemical	Regulated Exposure Limits/Risk Factors				Emissions Inventory		Hazard Quotient		Cancer Risk	
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary		Boundary		Boundary	
					MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	MEI ^{a,b} Annual	Worker 100 Meters 8 Hours ^c	MEI ^{a,d} Annual	Worker 100 Meters 8 Hours ^e
Acetylene	66.28	2,708	2,708	None	1.1x10 ⁻⁵	1.4x10 ⁻²	1.6x10 ⁻⁷	5.3x10 ⁻⁶	0	0
Ethanol	46.10	1,900	1,880	None	3.9x10 ⁻⁶	5.3x10 ⁻³	8.5x10 ⁻⁸	2.8x10 ⁻⁶	0	0
Methane (simple asphyxiant)	None	None	None	None	1.1x10 ⁻⁵	0.01	0	0	0	0
Methanol	1.75	260	200	None	3.9x10 ⁻⁶	5.3x10 ⁻³	2.2x10 ⁻⁶	2.0x10 ⁻⁵	0	0
Hazard Index^f							2.5x10 ⁻⁶	2.8x10 ⁻⁵		
Total Cancer Risk^g									0	0

^a MEI: maximally exposed individual of the public.^b Hazard Quotient for MEI: boundary annual emissions/Reference Concentration.^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.571 [fraction of lifetime working]) x (slope factor).^f Hazard Index: sum of individual hazard quotients.^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; SR DOE 1995a; SRS 1993a:3.

TABLE E.3.4-35.—Risk Assessments from Exposure to Hazardous Chemicals from Tritium Recycling Phaseout Function at Savannah River
Site [Page 1 of 2]

Regulated Exposure Limits/Risk Factors				Emissions Inventory				Hazard Quotient				Cancer Risk	
Chemical	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary MEI ^a Annual (mg/m ³)	Worker 100 Meters 8 Hours (mg/m ³)	Boundary MEI ^{a,b} Annual	Worker 100 Meters 8 Hours	Boundary MEI ^{a,d} Annual	Worker 100 Meters 8 Hours	Boundary MEI ^{a,d} Annual	Annual	8 Hours
Acrolein	0.00002	0.25	0.23	None	1.6x10 ⁻⁶	2.1x10 ⁻³	7.8x10 ⁻²	0.01	0	0	0	0	0
Acrylonitrile	0.002	4.42	4.3	0.24	1.6x10 ⁻⁶	2.1x10 ⁻³	7.8x10 ⁻⁴	4.8x10 ⁻⁴	1.1x10 ⁻⁷	2.0x10 ⁻⁵	0	0	0
Antimony	0.00001	0.50	0.5	None	9.2x10 ⁻⁷	1.2x10 ⁻³	6.6x10 ⁻²	2.5x10 ⁻³	0	0	0	0	0
Benzene	0.783	3.25	32.0	0.029	2.3x10 ⁻³	3.1	2.9x10 ⁻³	0.95	1.9x10 ⁻⁵	3.5x10 ⁻³	0	0	0
Cadmium	0.0005	0.2	0.05	None	9.2x10 ⁻⁷	1.3x10 ⁻³	1.8x10 ⁻³	6.3x10 ⁻³	0	0	0	0	0
Cadmium oxide	0.0025	0.1	0.05	None	1.1x10 ⁻⁶	1.4x10 ⁻³	4.2x10 ⁻⁴	0.01	0	0	0	0	0
Chlorine	0.039	1.5	1.5	None	1.2x10 ⁻⁴	0.16	3.1x10 ⁻³	0.11	0	0	0	0	0
2,4-Dinitrotoluene	0.0069	1.5	0.15	None	1.8x10 ⁻⁵	0.03	2.7x10 ⁻³	0.02	0	0	0	0	0
Diethyl phthalate	0.07	5.0	5.0	0.014	2.1x10 ⁻⁶	2.9x10 ⁻³	3.1x10 ⁻⁵	5.8x10 ⁻⁴	8.6x10 ⁻⁹	1.6x10 ⁻⁶	0	0	0
Ethyl benzene	1.0	435.0	434.0	None	2.1x10 ⁻⁵	0.03	2.1x10 ⁻⁵	6.7x10 ⁻⁵	0	0	0	0	0
Ethylene glycol	0.2	740.0	18.0	None	8.1x10 ⁻⁶	0.01	4.1x10 ⁻⁵	1.5x10 ⁻⁵	0	0	0	0	0
Formic acid	6.994	9.0	9.4	None	2.9x10 ⁻⁵	0.04	4.2x10 ⁻⁶	4.4x10 ⁻³	0	0	0	0	0
Hexane	0.2	1,800.0	176.0	None	4.1x10 ⁻⁶	5.5x10 ⁻³	2.0x10 ⁻⁵	3.1x10 ⁻⁶	0	0	0	0	0
Hydrogen chloride	0.007	7.0	7.0	None	2.9x10 ⁻³	3.9	0.41	0.55	0	0	0	0	0
Hydrogen sulfide	0.0009	14.0	14.0	None	8.3x10 ⁻⁵	0.11	0.09	8.1x10 ⁻³	0	0	0	0	0
Manganese	0.005	1.0	2.0	None	6.3x10 ⁻⁶	8.5x10 ⁻³	1.3x10 ⁻³	8.5x10 ⁻³	0	0	0	0	0
Mercury	0.0003	0.05	0.05	None	3.2x10 ⁻⁶	4.3x10 ⁻³	0.01	0.09	0	0	0	0	0
Methanol	1.75	260.0	200.0	None	6.2x10 ⁻⁶	8.5x10 ⁻³	3.6x10 ⁻⁶	3.3x10 ⁻⁵	0	0	0	0	0
Methylene chloride	3.0	1,765.0	177.0	0.0075	2.2x10 ⁻⁵	0.030	7.3x10 ⁻⁶	1.7x10 ⁻⁵	4.7x10 ⁻⁸	8.6x10 ⁻⁶	0	0	0
Methyl ethyl ketone (MEK)	1.0	590.0	590.0	0	8.1x10 ⁻⁵	0.11	8.1x10 ⁻⁵	1.8x10 ⁻⁴	0	0	0	0	0
Methyl tert-butyl ether	0.2	20.0		0	3.1x10 ⁻⁵	0.04	1.6x10 ⁻⁴	2.1x10 ⁻³	0	0	0	0	0
Methyl isobutyl ketone (MIBK)	0.05	205.0	205.00	0	4.2x10 ⁻⁵	0.06	8.4x10 ⁻⁴	2.8x10 ⁻⁴	0	0	0	0	0
Nickel	0.02	1.0	1.0	0.84	4.3x10 ⁻⁶	5.8x10 ⁻³	2.2x10 ⁻⁴	5.8x10 ⁻³	1.0x10 ⁻⁶	1.9x10 ⁻⁴	0	0	0
Nickel oxide	0.0012	0.1	0.1	0	9.2x10 ⁻⁷	1.2x10 ⁻³	7.7x10 ⁻⁴	0.01	0	0	0	0	0
Nitric acid	0.123	5.0	5.0	0	4.8x10 ⁻⁵	0.06	3.9x10 ⁻⁴	0.01	0	0	0	0	0

TABLE E.3.4-35.—Risk Assessments from Exposure to Hazardous Chemicals from Tritium Recycling Phaseout Function at Savannah River Site [Page 2 of 2]

Chemical	Regulated Exposure Limits/Risk Factors			Emissions Inventory			Hazard Quotient			Cancer Risk		
	Reference Concentration (mg/m ³)	Permissible Exposure Limit (mg/m ³)	Threshold Limit Value (mg/m ³)	Slope Factor (mg/kg/day)	Boundary		Annual	8 Hours	Worker 100 Meters	Boundary Annual	Worker 100 Meters	Boundary Annual
					MEI ^a	Annual (mg/m ³)						
Sodium hydroxide	0.0489	2.0	2.0	None	6.3x10 ⁻⁶	8.6x10 ⁻³	1.3x10 ⁻⁴	4.3x10 ⁻³	0	0	0	0
Sulfuric acid	0.0245	1.0	1.0	None	9.5x10 ⁻⁷	1.3x10 ⁻³	3.9x10 ⁻⁵	1.3x10 ⁻³	0	0	0	0
Tetrachloroethylene (PERC)	0.03497	170.0	339.0	None	5.3x10 ⁻⁴	0.72	0.02	4.2x10 ⁻³	0	0	0	0
1,1,1-Trichloroethane (111-TCA)	1.0	1,900.0	1,900.0	None	2.2x10 ⁻⁵	0.03	2.2x10 ⁻⁵	1.6x10 ⁻⁵	0	0	0	0
Trichloroethylene (TCE)	0.046	270.0	270.0	0.006	1.8x10 ⁻⁴	0.24	3.9x10 ⁻³	9.0x10 ⁻⁴	3.1x10 ⁻⁷	5.6x10 ⁻⁵	0	0
Trichloromethane (Chloroform)	0.03497	240.0	9.78	0.081	5.2x10 ⁻⁴	0.70	0.02	2.9x10 ⁻³	1.2x10 ⁻⁵	2.2x10 ⁻³	0	0
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	105.0	7,600.0	7,670.0	None	1.6x10 ⁻⁵	2.1x10 ⁻³	1.5x10 ⁻⁷	2.8x10 ⁻⁷	0	0	0	0
Toluene	0.4	375.0	377.0	None	2.8x10 ⁻⁵	0.04	7.1x10 ⁻⁵	1.0x10 ⁻⁴	0	0	0	0
Xylene	7.0	435.0	435.0	None	3.8x10 ⁻⁴	0.51	5.4x10 ⁻⁵	1.2x10 ⁻³	0	0	0	0
Hazard Index^f							0.7	1.8				
Total Cancer Risk^g									3.2x10⁻⁵			5.9x10⁻³

^a MEI: maximally exposed individual of the public.

^b Hazard Quotient for MEI: boundary annual emissions/reference concentration.

^c Hazard Quotient for Workers: 100-meter, 8-hr emissions/permissible exposure limit.

^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (0.237 [fraction of year exposed]) x (0.571 [fraction of lifetime working]) x (slope factor).

^f Hazard Index: sum of individual hazard quotients.

^g Total Cancer Risk: sum of individual cancer risks.

Source: Calculated from modeled data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; SR DOE 1995a; SRS 1993a:3.

TABLE E.3.4-36.—Risk Assessments from Exposure to Hazardous Chemicals at Savannah River Site—Summary Hazard Index and Total Cancer Risk

Technology ^a	Hazard Index		Total Cancer Risk	
	Boundary MEI ^{b, c} Annual	Worker 100 Meters 8 Hours ^b	Boundary MEI ^{d, e} Annual	Worker 100 Meters 8 Hours ^{d, f}
No Action	0.70	1.8	3.2x10 ⁻⁵	5.9x10 ⁻³
Tritium Recycling Upgrade	2.5x10 ⁻⁶	2.8x10 ⁻⁵	0	0
Heavy Water Reactor	3.7x10 ⁻⁶	2.9x10 ⁻⁵	0	0
Heavy Water Reactor and Tritium Recycling Upgrade	6.1x10 ⁻⁶	5.8x10 ⁻⁵	0	0
Heavy Water Reactor, Tritium Recycling Upgrade and No Action	0.70	1.8	3.2x10 ⁻⁵	5.9x10 ⁻³
Modular High Temperature Gas-Cooled Reactor	1.3x10 ⁻⁴	3.0x10 ⁻⁶	0	0
Modular High Temperature Gas-Cooled Reactor and Tritium Recycling Upgrade	1.4x10 ⁻⁴	3.1x10 ⁻⁵	0	0
Modular High Temperature Gas-Cooled Reactor, Tritium Recycling Upgrade, and No Action	0.70	1.8	3.2x10 ⁻⁵	5.9x10 ⁻³
Advanced Light Water Reactor	4.1x10 ⁻³	0.071	0	0
Advanced Light Water Reactor and Tritium Recycling Upgrade	4.1x10 ⁻³	0.071	0	0
Advanced Light Water Reactor, Tritium Recycling Upgrade, and No Action	0.70	1.9	0	0
Accelerated Production of Tritium	2.5x10 ⁻⁶	2.8x10 ⁻⁵	0	0
Accelerated Production of Tritium and Tritium Recycling Upgrade	4.9x10 ⁻⁶	5.7x10 ⁻⁵	0	0
Accelerated Production of Tritium, Tritium Recycling Upgrade, and No Action	0.70	1.8	3.2x10 ⁻⁵	5.9x10 ⁻³
Tritium Recycling Only	0.70	1.8	3.2x10 ⁻⁵	5.9x10 ⁻³

^a Combined Hazard Index and total cancer risk for these alternatives.

^b MEI: maximally exposed individual of the public.

^c Hazard Index: sum of individual Hazard Quotient.

^d Cancer Risk for MEI: (emissions concentrations) x (0.286 [converts concentrations to doses]) x (slope factor).

^e Total Cancer Risk: sum of individual cancer risks.

^f Cancer Risk for Workers: (emissions for 8-hr) x (0.286 [converts concentrations to doses]) x (slope factor).

Source: Calculated from model data derived from DOE 1995d; DOE 1995e; DOE 1995f; FDI 1994h; SNL 1995a; SRS 1993a.3.

E.4 HEALTH EFFECTS STUDIES: EPIDEMIOLOGY

Various epidemiologic studies have been conducted in the past at some of the sites evaluated in this PEIS because of the concern with the health effects of nuclear research, and the manufacture and testing of nuclear weapons. These studies are summarized below. With a few exceptions most epidemiologic studies of the populations living near the sites have been descriptive in nature and are what epidemiologists refer to as ecologic or correlational studies. Occupational epidemiologic studies, studies of workers, have been mostly analytical. The various epidemiologic studies, along with their assumptions and limitations, are described in section E.4.1.

E.4.1 Background

Nuclear weapons research and manufacture and consequent exposure began in the late 1930s and early 1940s. Very little knowledge was available at the time on the potential health effects from radiation exposure. As with many other chemicals, exposure levels to nuclear elements have changed over time with higher levels occurring in the early days of research and manufacture. Epidemiologic studies have been conducted to identify adverse health effects associated with nuclear use. Different epidemiologic methods have been used to assess these health effects; however, the epidemiologic methods for assessing occupational exposures have also evolved over time. For example, the use of multivariate methods for data analysis is a more recent phenomenon. The multivariate methods are more powerful in identifying causality than the ecologic and descriptive methods that were used more frequently just a few years ago. Thus, the review of the epidemiologic literature and the resulting findings basically reflect this change in study design over time.

E.4.1.1 Study Designs

Studies that have been conducted to assess the health effects resulting from exposure to nuclear radiation include ecologic studies, cohort studies, and case-control studies, which include the nested case-control design.

The unit of observation in *Ecological or Correlational Studies* is a group of people rather than an indi-

vidual (Rothman 1986a). Examples of groups may include classes in a school, factory workers, residents of a city, county, or nation. The health effects measured are frequently limited to the incidence (newly diagnosed cases) or mortality rates because these health indicators are readily available for the unit population under consideration. Exposure is defined as residence in the unit of observation and every person in the unit is assumed to be equally exposed whether they have resided in the unit for a very short time period or a very long time period or whether they even resided in the unit at the time of exposure. Exposure is also assumed to be limited to the unit of observation, a fact that may or may not be true for the 5 candidate sites because of the potential downwind emissions considered to be an important factor in population exposure. The unit of observation for the ecologic studies conducted around the PEIS sites is the county(ies) where the facility is located. Rates in these counties are compared to rates in counties farther away from the site. Because measurements are averaged over populations and because the measures of exposure are only proxies, the ecologic studies tend to attenuate any real associations between exposure and risks unless the risks of disease are very large. No control of confounding is possible in these studies, except for general population rates such as income, race, or crowding. Ecologic studies, however, are frequently used as an overall screening method to assess whether a major health problem exists. Ecologic studies are also relatively inexpensive to conduct compared to other epidemiologic studies because they use readily available data (mortality rates, cancer registry rates, census data) and can be done relatively quickly. Most population-based studies at the PEIS sites have been ecologic (correlational) studies.

The cohort (follow-up) method has been most frequently used to date for the analysis of occupational exposures. Cohort studies include the entire available study population, although some populations may be limited by employment or termination dates (RMOE 1989a). A cohort study requires the enumeration and follow-up of a population of individuals who are known to be exposed or not exposed to an agent of interest (although exposure measurements can be very general or very specific). Cohort follow-up studies can be prospective, where the cohort is identified at the beginning of the study and followed over time, or historical, where the cohort of

individuals, most frequently workers, is enumerated as of some time in the past and the health of the cohort is assessed over historical time to estimate disease rates. Most cohort follow-up studies conducted at the PEIS sites have been historical cohort studies. Traditionally, overall and cause-specific mortality rates have been assessed. More recently, overall and cause-specific cancer incidence (newly diagnosed) rates have also been assessed. Use of incidence rates, however, is limited to their availability. Rates in the exposed cohort are compared to those observed in a nonexposed population such as the national or regional populations (Standard Mortality or Incidence Ratios), or with subgroups of the cohort classified according to exposure type or level (relative risks, risk ratio, rate ratio). The advantage of the historical cohort design is that it allows follow-up of a large number of individuals (thousands) over a long period of time (years), which would not be feasible for prospective cohort studies (individuals could outlive the investigator). But the method also has its drawbacks. Past records are not readily available and may be incomplete or destroyed. Cohort studies are also expensive and time consuming since records for all subjects must be abstracted.

The case-control study design reduces cost and time by requiring that information be collected only for the cases and a sample of the cohort that generated the cases (the controls), thus mitigating the difficulties of following a large cohort over time. When used properly, case-control studies provide estimates of the relative risks (odds ratio) of cohort studies (RMOE 1989a). The problem with case-control studies is the identification of controls that are representative of the population that generated the cases. Some case-control studies have been used to study populations around some PEIS sites.

The nested case-control design avoids the problems of the general case-control study while taking advantage of its cost saving feature because of the limited number of individuals studied. In a nested case-control study, the enumerated cohort is restricted to the analysis of observed cases and a sample of other individuals free of the disease at the time when the disease in the cases occurred. Several nested case-control studies have been conducted among the workers at the PEIS sites (e.g., ORR). These studies provide estimates of the relative risks

(odds ratios) from cohort studies, and the results can be generalized to the entire cohort.

E.4.1.2 Definitions

Standardization: A method used to control the effects of age, gender, or other known differences when comparing two or more different populations. These methods are used to obtain expected numbers of cases. There are two main methods:

Direct Method: The disease rates in the study population are used and are multiplied by the number of individuals in the age-, gender-, or other grouping in the standard population to obtain the expected rates of disease for the study population if the study population had the same age-, gender-, or other characteristics of the standard population.

Indirect Method: Because of the small number of individuals in a study population the rates can be very unstable. When this happens, the standardization method of choice is the indirect method. The disease rates in the standard population are multiplied by the number of individuals in the age-, gender-, or other specific group in the study population to obtain the expected rate of disease in the study population if the study population had the same disease rates as the standard population given the study population's age, gender, or other distribution characteristics.

Standardized Mortality (Incidence) Ratio: The standard mortality ratio is the ratio of the number of events observed in the study group or population to the number that would be expected if the study group or population had the same rates as the standard (reference) population. These rates have been standardized to the same standard population distribution. Data from the United States population or state-specific populations are most frequently referenced when this rate is used. Standard mortality ratios are frequently used with ecologic and historical cohort follow-up studies. Lack of comparisons between standard mortality ratios from different populations and the healthy worker effect are two distinct disadvantages in using this rate.

Standardized Rate Ratio: A rate ratio in which the numerator and the denominator have been standardized to the same (standard) population distribution.

Relative Risk, Risk Ratio, Rate Ratio: The ratio of the risk of disease or death among the exposed to the risk among the unexposed. Also, the cumulative incidence rate in the exposed to the cumulative incidence rate in the unexposed.

Odd Ratio, also Cross-Product Ratio, and Relative Odds: The odds ratio is the ratio of the odds of getting the disease if exposed, to the odds of getting the disease if not exposed. Under certain conditions the Odd Ratio approximates the Rate Ratio.

Healthy Worker Effect: A phenomenon observed in studies of occupational diseases. Workers usually exhibit lower overall death or disease rates compared to the general population, due to the fact that the severely ill and disabled are excluded from employment. Rates from the general population may be inappropriate for comparison if this effect is not taken into consideration.

E.4.2 Idaho National Engineering Laboratory

Surrounding Communities. A population-based mortality study, carried out by the National Cancer Institute (NIH 1990a; AMA 1991a), examined cancer mortality within a 50-mile radius around several nuclear facilities including INEL. The Idaho study counties included Bingham, Butte, and Jefferson Counties. No excess cancer mortality was observed in the population living in counties surrounding INEL when compared to the United States population, or to the population in the three control counties (Fremont, Cassia, Power, Madison MT, Broadwater MT, Custer, Twin Falls, Lemhi, and Oneida) for each study county, or when time trends were assessed. The study is limited by its correlational approach and the large size of the geographic areas (counties) used for surrogate exposure measurements.

The Idaho Department of Health and Welfare (Epidemiology and Health Statistics group) completed a different community-based epidemiologic cancer morbidity (1978-1987) and mortality (1950-1989) study of two additional counties (Minidoka and Clark) also within a 50-mile radius near INEL. Clark County lies northeast, and Minidoka County lies southwest of INEL. Clark County population was 880 in 1988, while the 1988 population for Minidoka County was 20,100 (IN DHW 1991a). Cancer death and incidence rates of the Minidoka and Clark popu-

lations were compared to those of the entire Idaho population. No differences in age-adjusted mortality rates were observed in either county. The overall annualized cancer death rate for Minidoka County was 314/100,000 compared to 311.3/100,000 for the state (IN DHW 1991b). The cancer death rate for Clark County was 517.3/100,000 but because of the very small number of people living in Clark County this death rate may be very unstable.

An excess risk was reported, however, for cancer-specific incidence rates. Clark County had an excess of newly diagnosed radiogenic and nonradiogenic cancers, but of these only breast (8 observed, 3.6 expected), which is radiogenic, and lip cancer in males (3 observed, 0.3 expected), which is not radiogenic, were statistically significant. The number of cases, however, was very small and the confidence intervals were wide. Minidoka County also had an excess in radiogenic and nonradiogenic incident cancers; however, only lip (23 observed, 8 expected) and corpus uteri (40 observed, 24.2 expected), both nonradiogenic cancers, reached statistical significance. Since exposure and dose data from INEL were not used for these studies, the excess in cancers are just as likely to be associated with competing causes such as farming and/or smoking and may not be associated with the INEL site specifically. Exposure-related excesses may also be masked due to the imprecise comparisons made, the use of the correlational approach as a surrogate for exposure measurement, the large size geographic areas considered, and the small sample size.

Workers. Although no occupational epidemiologic studies have been conducted at INEL to date, according to the the National Institute for Occupational Safety and Health, one is currently underway, but no results are expected before 1997. The Centers for Disease Control and Prevention, as a result of the Memorandum of Understanding with the Department of Health and Human Services of 1991, is currently conducting a dose reconstruction study in anticipation of future epidemiologic community studies.

E.4.3 Nevada Test Site

Surrounding Communities. Because of the potential carcinogenic threat of radioactive fallout on the general population resulting from above-ground

nuclear weapons testing, epidemiologic studies have attempted to assess the cancer incidence and mortality among individuals living in the areas of potential fallout, including areas in Utah. A series of ecological studies showed contradictory results in potentially exposed children. Lyon examined the cancer mortality (leukemia and other) of children living in high and low fallout areas between 1944 and 1975 (NEJM 1979a). Only children born between 1951 and 1958 (period of above-ground testing) were considered as highly exposed if they lived in one of the high-exposure areas at the time of death (Utah was exposed to 26 nuclear tests from the Nevada Test Site (NTS) between 1951 and 1958). Cancer cause was obtained from the death certificates and were separated into leukemias and others. Results show that although Utah children experience an overall cancer mortality rate lower than U.S. children as a whole, children living in high-fallout areas had more leukemia deaths than children living in low fallout areas. Other cancers occurred at the same rate in both high and low fallout areas. The high-risk fallout area identified by Lyon et al. was questioned by Beck and Krey (Science 1983a) who reconstructed the total Cs^{137} inventory across the state of Utah (area near NTS). Their measurements showed that sections of northern Utah also had high levels of fallout and questioned the results of any comparisons made between residents of the North and those of the South. Land (Science 1984a) also re-examined cancer mortality reported by Lyon (NEJM 1979a) using the National Center for Health Statistics data which covered the period 1950 through 1978. The analyses examined a reported association between childhood leukemia and exposure to radioactive fallout from above-ground nuclear weapons tests in Nevada. The exposure group consisted of 17 rural counties in Utah which were downwind from the tests and the control group consisted of the remaining 12 northern counties of Idaho and no- or low-fallout regions outside Utah (Eastern Oregon and the State of Iowa). Although an excess of leukemia was reported for high exposure levels compared to low exposure levels, the data did not support a regional difference because leukemia rates were also significantly elevated in Oregon, an area of no fallout.

Another study that assessed the development of cancer among individuals potentially exposed to radioactive fallout has been reported by Rallison (HP 1990a). This study examined the thyroid cancer

risk in a cohort of children born between 1947 and 1954 in two counties near the nuclear test sites, one in Utah and one in Nevada. A comparison group of Arizona children was also evaluated. The children (11 to 18 years of age) were examined between 1965 and 1968 for thyroid abnormalities and were re-examined in 1985 and 1986. Like the ecological studies, however, exposure was based on geopolitical boundaries. Children living in the nuclear testing area had a higher rate of thyroid cancer but the differences were not statistically significant. Some examined children currently living in the high-fallout area at the time of examination were later found to have been living outside the high-fallout area at the time of exposure.

A more definitive study (AMA 1984a) examined the cancer incidence in an area of radioactive fallout downwind from NTS. This study consisted of two parts: an analysis of all Utah Mormons and a personal interview of individuals residing in a high-fallout area. Cancer incidence data for all Utah Mormons was available and two 9-year periods (1958 to 1966 and 1972 to 1980) were selected for the study. The average annual age-adjusted cancer incidence rate was reported as 228/100,000 for all Utah Mormons between 1967 and 1975. The cancers statistically significant at the 1 percent probability level for all Utah Mormons during both time periods were cancers of the thyroid (standard incident ratio (SIR)=4.3-8.2), bone (SIR=10.0-12.5), and leukemia (SIR= 5.28-3.5). The ratio of radiosensitive cancer to all other cancers was 53.3 percent higher in the early period (1958 to 1966) and 300 percent higher in the later period (1972 to 1980). The lower range of whole-body radiation associated with fallout symptoms in this study is about 50 rads.

Sixty percent of the 4,125 Mormons who were listed in the telephone directory in 1951 and in 1962 were located and interviewed in 1981. Information on personal habits, lifestyle, cancer, and reproduction was obtained for each family member. This study is one of the few where the investigators were able to interview the study subjects, where the reported cancers were verified, and where a comparable and appropriate comparison group was available. The cancer incidence was greater in this group compared to all Utah Mormons, but most cancers were reported in the period between 1958 and 1968 (stomach, leukemia, brain, and melanoma) and only a few

(breast and lymphoma) were statistically significant in the later time period (1972 to 1980). This part of the study would have been more powerful if the investigators had interviewed a comparable group of controls.

Cancers of all sites were significant at the 1 percent probability level for all groups studied and for all time periods under consideration.

Machado (AJE 1987a) examined the cancer mortality experience of a three-county region in southwestern Utah using a correlational cross sectional mortality study and compared the cancer mortality there with that from the rest of Utah. This study confirmed the excess leukemia reported by Johnson (AMA 1984a) but could not confirm the excess cancers at other sites. Because the studies have different designs they cannot easily be directly compared.

Archer (AEH 1987a) measured soil, milk, and bone strontium-90 levels to identify states with high, intermediate, and low fallout contamination. He then correlated the deaths from radiogenic and nonradiogenic leukemias with the time periods of above-ground nuclear testing both in the United States and Asia. The results show that leukemia deaths in children were higher in states with high exposure and lower in states with less exposure. He showed that leukemia deaths in children peaked approximately 5.5 years following nuclear testing peaks. The last leukemia peak in the United States occurred in 1968 to 1969, 5.5 years after the last year of a 3-year period of intensive testing in Asia. The increases were seen in the radiogenic leukemias (myeloid and acute leukemias), and not with "all other leukemias."

Workers. An excess number of leukemia cases was reported (9 cases, 3.5 expected) among the 3,224 men who participated in military maneuvers in 1957 at the time of the nuclear test explosion "Smoky" (AMA 1980a; AMA 1983a). The participants were located and queried on their health status, diseases, or hospitalizations as of December 1981. A next of kin was queried about cause of death for those participants who were deceased. Exposure information was available from film badges and ranged from 40 to 1,834 mrem. In the later report (AMA 1983a), the number of incident cases of leukemia had increased to 10 with 4 expected. No excess in "total

cancers" was observed, however. In addition, four cases of polycythemia vera were reported where 0.2 was expected (AMA 1984a). The excess in leukemia cancer incidence and mortality appear to be limited to the soldiers who participated in "Smoky." The excess was not observed in a National Research Council mortality study of soldiers exposed to five series of tests at two sites: Nevada Test Site (PLUMBBOB) and the Pacific Proving Ground (National 1985a). The NRC reported that the number of leukemia cases in "Smoky" was greater but the increase was considered nonsignificant when analyzed with the data from the other four tests.

Re-analysis of the National Research Council report on the *Mortality of Nuclear Weapons Test Participants* released on June 4, 1985, showed a 62-percent excess cancer among soldiers involved in the nuclear test explosion PLUMBBOB ("Smoky" was part of PLUMBBOB) who were exposed to 300 mrem or more (AJE 1987a). The excess was observed for leukemia and aleukemia as well as the other cancer group. The original analyses acknowledged the healthy worker bias when the expected mortality values were obtained from the general population but the method of analysis did not control for the problem in the original study. The reanalysis avoided the problem by considering a dose response analysis. Two exposure groups were considered: ≥ 300 mrem and < 300 mrem. The excess was observed in the group exposed to more than 300 mrem. The reanalysis also reports an elevated risk of death from respiratory cancers for "Smoky" participants (Cancer Mortality Ratio=2.28, $p < 0.01$) and an excess risk of "other" (Ratio=1.75, $p < 0.01$) and "all cancers" (Ratio=1.49, $p < 0.01$) for the other participants of "PLUMBBOB."

E.4.4 Oak Ridge Reservation

More epidemiologic studies have been carried out to assess the health effects of the population living near or working at the ORR facilities in Tennessee than at any other site reviewed for the PEIS.

Surrounding Communities. The population-based National Cancer Institute mortality survey for selected nuclear facilities (NIH 1990a; AMA 1991a) examined the cancer mortality within a 50-mile radius around several nuclear facilities including Anderson and Roane counties. No excess cancer

mortality was observed in the population living in the exposed counties when compared to the United States white male population, nor when compared to the population of the control counties (Blount, Bradley, Coffee, Jefferson, Hamblen, TN, and Henderson, NC), nor when time trends were assessed.

The Tennessee Cancer Reporting System (OR DHE 1992a) of the Tennessee Department of Health and Environment also evaluated the cancer incidence and cancer mortality rates for Anderson and Roane counties and compared them with the average rates of 72 U.S. cities. Slight excesses in cancer incidence and overall mortality rates were observed, none of which were statistically significant. For Anderson County, there was a slight excess in the incidence of myelomas (observed to expected (O/E) ratio is 1.58), and cancers of the lung and bronchus (O/E=1.21), esophagus (O/E=2.19), and cervix uteri (O/E=1.89). For Roane County, a slight excess in the incidence of cancers of the bone and joints (O/E=2.50), lung and bronchus (O/E=1.40), oral cavity and pharynx (O/E=1.59), and stomach and small intestines (O/E=1.27) was reported. Mortality rates were elevated for respiratory cancers (O/E=1.24) and for cancers of the skin (O/E=2.6) in Anderson County, and for cancers of "other lymphatic and hematopoietic tissue" (O/E=1.45), respiratory and intrathoracic organs (O/E=1.32), and for unspecified and "all other cancers" (O/E=1.26) in Roane County. The only consistent excess reported for both cancer incidence and cancer mortality rates occur with cancer of the respiratory and intrathoracic organs, an excess which may be confounded by smoking.

The two population-based studies mentioned above are limited by their correlational approach and the large size of the geographic areas (counties) used.

Because of a concern for possible contamination of the population by mercury, the Tennessee Department of Health and Environment conducted a pilot study in 1984 (OR DHE 1984a). The study showed no difference in urine or hair mercury levels between individuals with potentially high mercury exposures (residence or activity in contaminated areas based on soil measurements or consumption of fish caught in the contaminated areas) compared to those with little potential exposure.¹ Mercury levels in some soils measured as high as 2,000 parts per million (ppm).

Analysis of a few soil samples showed that most of the mercury in the soil, however, was inorganic thereby lowering the probability of bioaccumulation and health effects. Examination of the long-term effects of exposure to mercury and other chemicals continues.

Workers: Radiation. Between 1943 and 1985, there were 118,588 male and female individuals of all races who were ever employed in any of the Oak Ridge facilities. These included the Oak Ridge National Laboratory for nuclear research (also called the X-10 facility), Y-12 plant under management of the Tennessee-Eastman Corporation (1943 to 1947) which produced enriched uranium by the electromagnetic separation process, Y-12 under management of Union Carbide (1948 to 1984) which fabricated and certified nuclear weapons parts, and K-25 (Oak Ridge Gaseous Diffusion Plant) which produced enriched uranium through the gaseous process. Analyses at the Oak Ridge facilities have been carried out mostly for white males, and for specific cohorts taking into consideration time-related exposure risks. All mortality rates were compared to that of United States white males unless otherwise specified.

Oak Ridge National Laboratory. An excess of leukemia deaths (standard mortality ratio (SMR))=1.48; 95 percent Confidence Interval (CI)=0.31-4.38) among 8,375 white male Oak Ridge National Laboratory workers employed between January 1, 1943, and December 31, 1972, was reported by Checkoway et al., (1985). The study excluded workers known to have worked at other nuclear facilities. Data from film badges used since 1951 provided an assessment of external penetrating radiation exposure. An elevated SMR was also reported for prostate cancer and Hodgkin's disease. No dose response, however, was observed for prostate cancer and Hodgkin's disease, and the numbers were too small to be statistically meaningful. The excess leukemia deaths reported in this study occurred mostly among maintenance workers and engineers who had worked for more than 10 years, suggesting a possible excess attributed to

1. Approximately 200,000 to 470,000 pounds of mercury were discharged into the East Fork Poplar Creek located near the Y-12 facility between 1953 and 1977. Discharges of about 2 ounces per day continued until 1983. These discharges were the result of routine releases from the New Hope Pond, a settling pond for the Y-12 facility.

exposures other than radiation. Maintenance workers are exposed to a number of solvents, metals, and welding fumes. No attempt was made in this analysis to control for confounders such as smoking and socioeconomic status.

The excess of leukemia deaths reported by Checkoway et al. (BJIM 1985a) was confirmed by Wing (AMA 1991a; AJIM 1993a) when the cohort of white males ($n=8,318$) was followed through 1984 (SMR=1.63; 95 percent CI=1.08-2.35 for all workers; SMR=2.23; 95 percent CI=1.27-3.62 for workers monitored for internal contamination). An estimated percentage increase for leukemia rose from 6.38 percent for an exposure lag of 0 years to 9.15 percent with a 10-year lag. Of the 30 leukemia deaths in the cohort, 2 (0.7 expected) occurred in the radioisotope group, 2 (0.5 expected) occurred in the chemical operations group, and 5 (2.3 expected) occurred in the engineering research and development group.

An increase of 2.68 percent in deaths from "all causes" and 4.94 percent for "all cancers" with every 10 million Sieverts (1 rem) of cumulative dose exposure with a 20-year exposure lag was also reported by Wing (AMA 1991a; AJIM 1993a). Adjustments for confounders such as job category; socioeconomic status; World War II employment; and exposure to beryllium, lead, and mercury had little or no effect on the excess risk observed. Risk estimates between cumulative exposure to low levels of external penetrating ionizing radiation and "all cause" mortality were shown to be several times the risk estimates obtained from the Japanese A-bomb survivor data for low-level radiation. This excess increased with increasing dose regardless of exposure lag time, and was stronger for exposures that occurred 20 years in the past. The excess deaths due to ill-defined causes (SMR=2.34; 95 percent CI=1.76-3.05 for all workers; SMR=2.89; 95 percent CI=1.93-4.14 for workers monitored for internal contamination) was also statistically significant. These increases remained consistent regardless of whether confounders (active work, pay code, cohort, and continuous or categorical age) were considered. Deaths from lung cancer increased 5 percent for every 10 million Sieverts (1 rem) of exposure (AMA 1991a; AJIM 1993a).

The excess in cancer deaths was associated with working in radioisotope production and chemical operations but not with work in physics, engineering, or unknown job categories. Cancer mortality was also associated with exposure to beryllium, lead, and mercury. Control of these chemicals, as well as the job exposure variable in a Poisson regression model, did not significantly affect the initial dose-response relationship observed between external low-level radiation and leukemia risks.

Y-12 Plant. Internal radiation exposure by inhalation of uranium compounds was the major concern for workers at the Y-12 Plant (Y-12) under Union Carbide management employed between 1947 and 1969 ($n=4,988$) and followed to 1973. An elevated but not statistically significant SMR for cancer of the brain (SMR=1.97 with 7 observed and 3.56 expected; 95 percent CI=0.79-4.06) was reported in this cohort when compared to U.S. white males (Polednak 1980a).

The effect of alpha (internal) and gamma (external) radiation was reported by Checkoway (AJE 1988a). The cohort was restricted to 6,781 white males employed for at least 30 days and who worked between May 4, 1947, and December 12, 1974, at the Y-12 facility. Employees who worked at another nuclear facility and any worker employed prior to 1947 were excluded from the analyses (a major shift from uranium enrichment to fabrication of weapons' parts and research and development for separation of isotopes of other compounds occurred in 1947). Exposure data were available from film badges and urinalyses. Urinalysis data were converted to estimates of lung dose equivalents through the use of metabolic models. Observed mortality rates were compared to those from the U.S. white male population and to that of Tennessee white males. An excess of lung cancer mortality was observed in this cohort (SMR=1.36; 95 percent CI=1.09-1.67 when compared to the U.S. white male rates; SMR=1.18; 95 percent CI=0.95-1.45 when compared to rates from Tennessee white males). A dose-response effect appeared related to the alpha (internal) and gamma (external) radiation with the most pronounced effect observed for gamma radiation among workers exposed to 5 rems of alpha radiation. At zero-year latency assumption, the dose-response was very pronounced for workers with both 5 rems or more of alpha and gamma radiation (Rate Ratio (RR)=4.60;

95 percent CI=0.91-23.4). The effect was weaker when a latency of 10 years was considered (RR=3.05; 95 percent; CI=0.37-24.83), suggesting that the effect may not be related to radiation. However, the estimates were based on a small number of cases (3 deaths at zero-year latency and 1 death at 10 ten-year latency) and consequently lack statistical precision. The period of observation would need to be extended for the study to have sufficient power to detect a moderate effect. Checkoway (AJE 1988a) also reported an excess of brain and central nervous cancers in this cohort (SMR=1.80; 95 percent CI=0.98-3.02 when compared to rates of U.S. white males; SMR=1.42; 95 percent CI=0.78-2.38 when compared to rates of Tennessee white males) but no dose response relationship was observed.

Polednak also reported on the mortality experience of white male workers employed at the Y-12 facility while under Tennessee-Eastman Corporation management between 1943 and 1947 (Polednak 1980a). These workers (n=4,008) were followed through 1973. The cohort excluded workers who continued employment after the shift in 1947 and those who worked for any other ORR facility. Exposure to external penetrating and internal radiation from uranium dusts was of concern for the Tennessee-Eastman Corporation workers. Compared to U.S. white males, the SMRs for white Tennessee-Eastman Corporation males who worked 1 year or longer was elevated for cancer of the testis (1.92), benign neoplasms (1.45), all diseases of the bones and organs of movement (3.22; 4 of the 6 deaths were due to rheumatoid arthritis), and "symptoms, senility, and ill-defined conditions" (1.77). Although the investigator reported that the 95 percent confidence estimates were calculated, none were presented in the tables.

An elevated risk for brain cancer was reported among 4,988 white males (Pedant 1980a) employed between 1947 and 1969 (Y12 workers under Union Carbide) but the excess was not statistically significant (SMR=1.97; 95 percent CI=0.79-4.06).

A follow-up through 1974 of all 18,869 workers employed at the Y-12 facility while under the TEC management between 1943 and 1947 was reported by Pedant and Frome (JOM 1981a). The workers included those exposed to internal ("alpha"), external

("beta") radiation through the inhalation of uranium dusts, electrical workers who performed maintenance in the exposed areas, and other non-exposed workers. Elevated but not statistically significant SMRs were observed in this cohort for mental, psychoneurotic, personality disorders (SMR=1.36), diseases of the bones and organs of movement (SMR=1.22), and symptoms, senility, and ill-defined conditions (SMR=2.80). No elevated SMRs were observed for cancer of the bones and for leukemia. The crude SMR for lung cancer was 1.09 (95 percent CI=0.97-1.22) but when adjusted for incomplete retrieval of death certificates, the SMR was significant (SMR=1.22; 95 percent CI=1.11-1.36). Cancer of the lung was greater among workers employed for 1 year or more compared to workers employed less than 1 year, and was more pronounced in workers hired at the age of 45 or older (odds ratio=1.51; 95 percent CI=1.01-2.31). Of the workers employed after the age of 44, the SMR for lung cancer was greater for electrical workers (SMR=1.55) confirming the excess observed in the earlier analysis, for alpha chemistry workers (SMR=3.02), and for beta process workers (SMR=1.51).

Combined Oak Ridge National Laboratory Facilities. Frome reported on the mortality experience of World War II workers employed at three ORR facilities between 1943 and 1947 using poisson regression analyses to control for potential confounders (such as facility TEC, K-25, X-10, or multiple), socioeconomic status using pay code (hourly, monthly), length of employment, period of follow-up, and birth earlier 1990a). The cohort included only white males who worked at ORR at least 30 days between the start of the operation and the end of the study (December 31, 1947), and at no other time after that date. The regression analyses confirmed the significantly elevated standard mortality ratios observed for deaths from tuberculosis (SMR=1.37), from mental, psychoneurotic, and personality disorders (SMR=1.60), and symptoms of senility, ill-defined conditions (SMR=3.05) reported by Polednak (1980a). No deaths were associated with exposure to radiation, however. The regression analysis showed a significant association with socioeconomic status as measured by job skill.

Carpenter investigated the earlier reports of an association between the excess number of brain cancers

and employment at the Oak Ridge National Laboratory and the Y-12 Plant in a case-control study among workers employed between 1943 and 1977 (AJIM 1988a). Cases consisted of 72 white males and 17 white females. Four controls were selected for each case and matched on age, sex, cohort, year of birth, and year of hire. No statistically significant association between the use of 26 chemicals evaluated and an increased risk of brain cancer was observed. The chemicals evaluated included those encountered in welding fumes, beryllium, mercury, 4,4'-methylene bis 2-chloroaniline or MOCA, cutting oils, thorium, methylene chloride, and other solvents. However, the excess brain cancer was observed among individuals employed for more than 20 years (odds ratio=7.0; 95 percent CI=1.2-41.1; cases=9). Analyses of these cases and controls with respect to internal and external radiation exposures revealed no association between radiation exposures and development of brain cancer (JOM 1987a). However, analysis of 82 cases with complete medical records revealed an excess risk of brain cancer with a history of epilepsy (odds ratio=5.7; 95 percent CI=1.0-32.1) as recorded in the medical records for pre-employment and health status follow-up (AJPH 1987a). Brain cancer of glial origin (4 cases and 0 controls) was strongly associated with a history of epilepsy.

Combined Nuclear Sites. ORR workers were also included in a combined analysis of Hanford Site, ORR, and Rocky Flats Plant (now known as Rocky Flats Environmental Technology Site) workers (RR 1989a). White male workers employed at one of the three facilities for at least 6 months and who were monitored for external radiation were included in the study. Analyses were based on the same vital status and cause of death information previously reported. Deaths were considered through 1981 for Hanford, through 1977 for ORR, and through 1979 for Rocky Flats Plant. Hanford contributed 23,704 workers, ORR contributed 6,332 workers, and Rocky Flats Plant contributed 5,897 workers. External radiation doses were obtained from the dosimeters worn by these workers. A check for possible overlap of the Hanford and Rocky Flats Plant cohorts identified 78 workers who qualified in both study populations. These workers were included in the cohort of the facility where they first met eligibility and the dose accumulated at the second facility was not included. These analyses provide no evidence of a correlation

between radiation exposure and mortality from all cancer or from leukemia and no evidence of chronic low dose exposure with any form of cancer mortality at ORR. Multiple myeloma was the only cancer found to exhibit a statistically significant correlation with radiation exposure in this multi-site analysis. However, all cases were contributed by the Hanford cohort (i.e., none was from ORR).

Workers: Chemicals and Metals. Only a few studies have examined the mortality of ORR workers exposed to other chemicals or metals. Polednak reported elevated mortality rates for white male workers exposed to phosgene while employed at Y-12 between 1943 and 1947 and followed through 1974 (ER 1980a). The SMR for symptoms, senility, and ill-defined conditions was 4.02 (95 percent CI=1.61-8.28) compared to the United States white males. The SMR, however, was also elevated among workers not exposed to phosgene (SMR=3.23; 95 percent CI=2.62-3.97). Although not statistically significant, the analysis shows an elevated SMR for all infective and parasitic disease (SMR=1.22; 95 percent CI=0.4-2.84) among workers with low to moderate phosgene exposure, and which was not observed among workers not exposed to phosgene (SMR=0.80; 95 percent CI=0.62-1.04). The excess was due mostly to tuberculosis among exposed workers who had no prior history of tuberculosis. Among workers highly exposed to phosgene, an elevated but not statistically significant SMR for external causes of death (accidents) was also reported (SMR=1.62; 95 percent CI=0.52-3.77). This designation (external causes of death) includes acute chemical poisoning and at least one of the four deaths is known to have resulted from phosgene poisoning. The investigator expresses concern about one death attributed to paranoid schizophrenia since dementia precox (schizophrenia) associated with phosgene exposure was previously reported in the literature. With only 106 heavily exposed workers, the numbers are too small to identify any trends in mortality. The results of this study also highlight the problem when analyses focus only on mortality and not morbidity.

Cragle reported on the mortality experience of 2,133 Y-12 workers exposed to elemental mercury vapors used in the lithium isotope separation process (JOM 1984a). Exposure for these workers was documented through urinalysis measurements. Another

270 workers were employed in the same departments as those who were monitored and, therefore, were probably exposed. Finally, 3,530 workers were never exposed. The mortality of all groups was compared to the mortality experience of U.S. white males. No statistically significant excess mortality was observed for workers exposed to mercury. The excess mortality observed for cancer of the brain and the lung was observed for all three groups and cannot be attributed to mercury exposure. Why the exposed and nonexposed were not compared using Poisson regression model or a contingency table analysis is not known but may have shed some light on mercury-specific effects. The investigators do point out, however, that mercury may exert its effects more on morbidity than on mortality.

Cragle reported on the mortality experience of the workers at the Oak Ridge Gaseous Diffusion Plant (IARC 1984a). Within this group, 800 white males were exposed to nickel powder and 7,500 workers were never exposed to nickel or the "barrier" material. Deaths in the exposed and nonexposed were compared to the mortality experience of U.S. white males. Statistically significant SMRs were observed for symptoms, senility, and ill-defined causes for both exposed (SMR=5.93; 95 percent CI=2.96-10.61) and nonexposed (SMR=3.25; 95 percent CI=2.54-4.10) workers and consequently cannot be attributed to nickel exposures. Elevated but not statistically significant SMRs were observed for cancers of the buccal cavity, liver, pancreas, and skin for the exposed workers and but not for the unexposed workers. When direct adjustments were made, all SMRs were lower than expected but the SMRs were higher in the exposed group for cancers of the buccal cavity, liver, and pancreas.

E.4.5 Pantex Plant

Surrounding Communities. Incidence data from the residents of the southwestern quadrant of Carson County (zip code area 79068) nearest Pantex, which was collected between 1980 and 1990, were compared with age-, gender-, and race-specific cancer incidence in five Public Health Regions of Texas that had complete cancer reporting since 1976. This study was carried out by the Texas Department of Health (PX DOH 1992a; PX DOH 1992). The Standardized Incidence Rate for the overall cancer incidence in the Carson County area of interest was

0.84 for males (72 cancers were reported; 85.75 were expected) and 0.88 for females (63 cancers were reported; 71.96 were expected). The only cancers with elevated but statistically nonsignificant Standardized Incidence Rates were cancer of the brain (SIR=1.82; 95 percent CI=0.22-6.57 in females with 2 cases observed and 1.1 expected) and leukemia (SIR=1.32; 95 percent CI=0.36-3.37 in males with 4 cases observed and 3.04 expected; SIR=2.11; 95 percent CI=0.69-4.92 in females with 5 cases observed and 2.37 expected). The wide confidence intervals indicating a decrease in precision can be explained by the small number of cases.

Mortality data were obtained from the Bureau of Vital Statistics and consisted of all who died of cancer between 1980 and 1991 in the zip code of interest. The comparison group for the mortality study consisted of age-, gender-, and race-specific rates for Texas during the years 1981-1989. The results for the mortality study were similar to those observed for the incidence study, with no significant increases in cancer mortality identified.

Workers. Acquavella compared the mortality experience of Pantex workers employed between 1951 and 1978 with that of U.S. white males (HP 1985a). Exposure information on workers was available from film badges, but only since 1963. Only data for white males (3,564) were reported because of the small number of females (892) and nonwhites (154). The results show a possible healthy worker effect. The Standard Mortality Ratio (SMR) for "all cause" mortality was significantly less than expected (SMR=0.72; 95 percent CI=0.64-0.85) with 269 observed deaths and 373.71 expected. The same was true for all the cause-specific deaths except brain cancer (SMR=1.36; 95 percent CI=0.37-3.47) and leukemia (SMR=1.28; 95 percent CI=0.35-3.27). The numbers observed (brain=4; leukemia=4) and the numbers expected (brain=2.95; leukemia=3.13) were so small, however, that the excess could be attributed to chance alone.

This study has limitations that restrict the conclusions that can be drawn. First, the comparison group (U.S. white males) does not take into consideration the healthy worker effect. A more appropriate comparison group would include nonexposed workers, or workers exposed at various radiation levels. Secondly, the cohort was followed on the average for

only 14.6 years. Except for the leukemias, most cancers generally have a latency period (time between cancer initiation and diagnosis) of 20 to 40 years. The period of follow-up is inadequate to identify an excess in cancer mortality except for leukemias, and the sample size is inadequate to determine any but the largest differences.

E.4.6 Savannah River Site

Surrounding Communities. The Savannah River Site, established in 1953 in Aiken, SC, produces plutonium and tritium and other nuclear materials. There are reports that millions of curies of tritium have been released over the years both in plant exhaust plumes and in ground and surface water streams (ED 1982a). Only two epidemiologic studies have been done at the Savannah River Site. They are summarized below.

In 1979, Sauer (as reported by Johnson, 1982) reported an excess of leukemia and lung cancer deaths among individuals living within a 50-mile radius of SRS compared to whites living between 50 and 99 miles away. Other excesses in mortality were observed but were statistically nonsignificant. Comparison groups in Sauer's study consisted of U.S. death rates and rates for counties more than 50 miles from SRS. More current correlation analyses of cancer incidence and deaths reveal no excess leukemia and no excess of other cancers.

The most comprehensive of the recent studies was the National Cancer Institute Study (NIH 1990a; AMA 1991a) that examined cancer mortality around nuclear facilities. Exposure was based solely on geopolitical boundaries. Barnwell County was considered the exposed county and Chester, Georgetown, and Sumter counties were considered control counties. The analyses compared the mortality experience in exposed counties with the mortality experience of nonexposed counties and with the mortality experience of U.S. white males. In addition, the mortality experience in the exposed counties occurring before the facility was built was compared with the mortality experience in the same counties after the facility was built. No excess cancer mortality was observed in the population surrounding any facility when compared to the control counties, the U.S. rates, or when the time trends were assessed.

Other community studies are being planned. A tumor registry has been in operation for a few years in South Carolina and Georgia, which covers the area around the site. Emory University investigators are currently analyzing data from the Georgia side of the plant while investigators at the University of South Carolina are analyzing data on the South Carolina side.

Workers. Evidence of an excess number of leukemia deaths has been reported in hourly workers at the Savannah River Plant (AJIM 1988a). Retrospective and prospective epidemiologic studies are being planned as part of a survey of plutonium workers at four Department of Energy facilities (Los Alamos National Laboratory, Mound Plant, Rocky Flats Plant, and SRS).

