WSRC-RP-97-311

COMPOSITE ANALYSIS

E-AREA VAULTS AND SALTSTONE DISPOSAL FACILITIES

Rev. 0

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Westinghouse Savannah River Company
Savannah River Site
Aiken, S.C. 29808

SAFETY • RESPONSIBILITY • SECURITY
SRS
SAVANNAH RIVER SITE

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ACRONYMS

ACRI	Analytic and Computations Research, Inc.
ALARA	As Low As Reasonably Achievable
AMSL	above mean sea level
ARARs	Applicable or Relevant and Appropriate Requirements
CB/TS	Core Barrell/Thermal Shield
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIF	Consolidated Incineration Facility
D&D	Decommissioning and Decontamination
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DQA	Data Quality Assessment
DQOs	Data Quality Objectives
DWPF	Defense Waste Processing Facility
EAV	E-Area Vaults
EPA	Environmental Protection Agency
ER	Environmental Restoration
ESP	Extended Sludge Processing
ETF	Effluent Treatment Facility
FBSB	Ford Building Seepage Basin
FBWS	Ford Building Waste Site
FMB	Fourmile Branch
GSA	General Separations Area
HLW	High-Level Waste
IAW	Intermediate Activity Waste
ICCG	Preconditioned Conjugate Gradient
INEL	Idaho National Engineering Laboratory
ITP	In Tank Precipitation
KAPL	Knolls Atomic Power Laboratory
LADTAP	Liquid Annual Doses to All Persons
LAW	Low Activity Waste
LLW	Low-Level Waste
MW	Mixed Waste
MWMF	Mixed Waste Management Facility
NRC	Nuclean Regulatory Commission
OBG	Old Burial Ground
OWST	Organic Waste Storage Tank
PA	Performance Assessment
QA	Quality Assurance
QC	Quality Control
RAE	Rogers and Associates Engineering Corporation

ACRONYMS (CONT'D)

RCRA	Resource Conservation and Recovery Act
SDCF	Soil/Debris Consolidated Facility
SDF	Saltstone Disposal Facility
SMSA	Standard Metropolitan Statistical Area
SPF	Saltstone Processing Facility
SR	Savannah River
SRLSBs	Savannah River Laboratory Seepage Basins
SRS	Savannah River Site
SRTC	Savannah River Technology Center
TNXBG	TNX Burial Ground
TRU	Transuranic
TV	Trigger Value
USGS	United States Geological Survey
UTR	Upper Three Runs
WSRC	Westinghouse Savannah River Company

UNITS OF MEASURE

mrem	millirem
km	kilometer
m	meter
mR/hr	milliRad per hour
cm/yr	centimeter per year
hr	hour
m/m	meter per meter
m/km	meter per kilometer
m/s	meter per second
cm/s	centimeter per second
g/cm^3	grams per cubic centimeter
cfs	cubic feet per second
m^3/s	cubic meters per second
$kg/m^2/yr$	kilograms per square meter per year

1.0 SUMMARY AND CONCLUSIONS

This report documents the Composite Analysis (CA) performed on the two active Savannah River Site (SRS) low-level radioactive waste (LLW) disposal facilities. The facilities are the Z-Area Saltstone Disposal Facility and the E-Area Vaults (EAV) Disposal Facility. The analysis calculated potential releases to the environment from all sources of residual radioactive material expected to remain in the General Separations Area (GSA). The GSA is the central part of SRS and contains all of the waste disposal facilities, chemical separations facilities and associated high-level waste storage facilities as well as numerous other sources of radioactive material. The analysis considered 114 potential sources of radioactive material containing 115 radionuclides. The results of the CA clearly indicate that continued disposal of low-level waste in the Saltstone and EAV facilities, consistent with their respective radiological performance assessments, will have no adverse impact on future members of the public

Figures 1-1 and 1-2 summarize the results of the CA. As shown in Figure 1-1, the calculated maximum dose to a hypothetical future member of the public is 14 mrem/year at the mouth of Four Mile Branch, 1.8 mrem/year at the mouth of Upper Three Runs, and 0.1 mrem/year on the Savannah River at the highway 301 bridge. The calculated maximum collective dose to a hypothetical future population is 2.7 person-rem/year, as shown in Figure 1-2. The radionuclides contributing the majority of the dose are ^{3}H, ^{14}C, ^{237}Np and isotopes of uranium. Two former LLW disposal facilities, the Mixed Waste Management Facility and the Old Burial Grounds, are the major sources of these isotopes. Based on the low calculated doses, a quantitative ALARA analysis of disposal options was not deemed necessary in this iteration of the CA.

DOE's commitment in the Defense Nuclear Facility Safety Board 94-2 Implementation Plan was to prepare a CA that evaluates the impact to a hypothetical future member of the public from all radioactive sources that potentially interact with LLW disposal facilities. Therefore, the CA considered interaction of radionuclide sources in the GSA with the active E and Z Area disposal facilities. Due to the groundwater divide between the Old Burial Ground and the Mixed Waste Management Facility, contaminants that potentially interact with EAV and Saltstone facilities are directed to Upper Three Runs. Therefore, the mouth of Upper Three Runs is the appropriate point to assess the effect of sources that potentially interact with E and Z Areas. The calculated maximum dose of 1.8 mrem/yr at the mouth of Upper Three Runs is well below the DOE primary dose limit of 100 mrem/yr and dose constraint of 30 mrem/yr. The CA included for completeness the assessment of the mouth of Four Mile Branch and the Savannah River at the Highway 301 bridge. It should be noted that the calculated maximum doses at these points are also below the DOE dose limit and constraint.

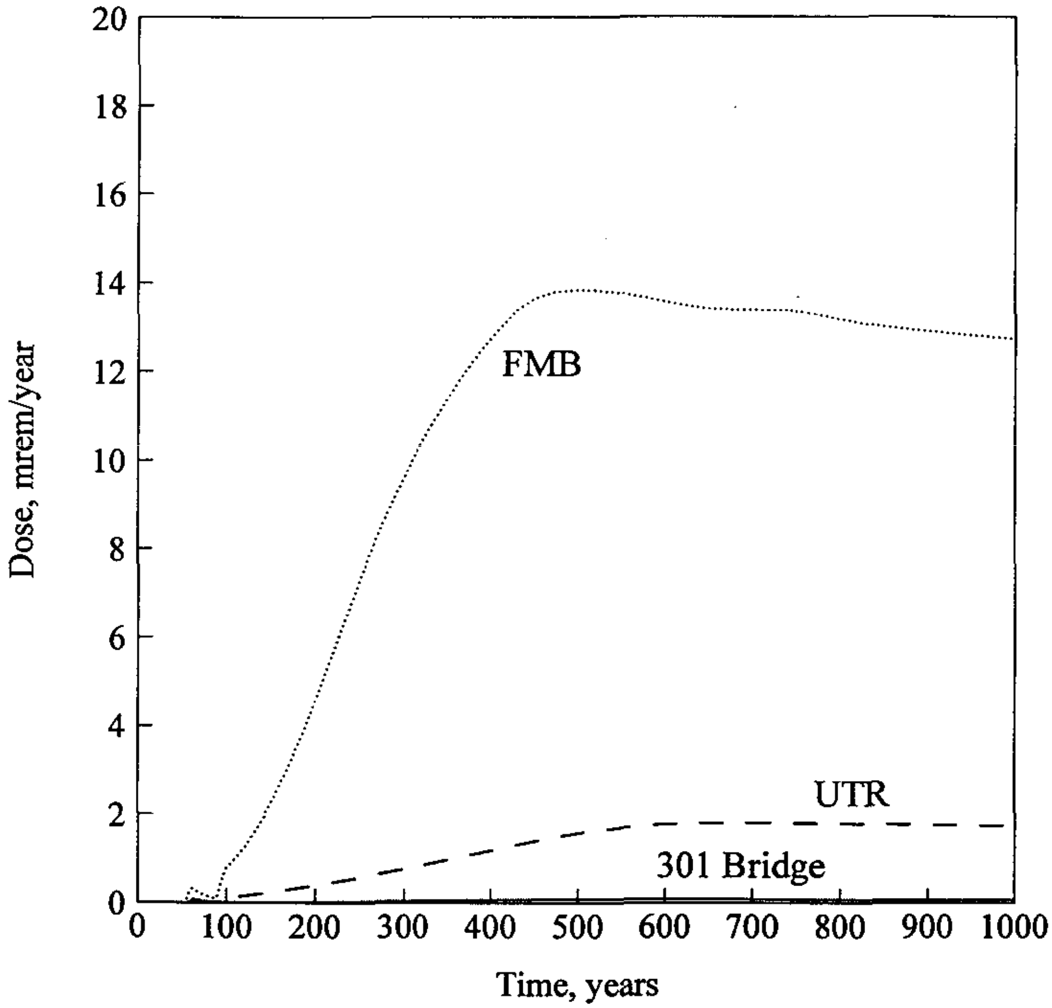

Figure 1-1. Dose to the maximally exposed individual at the mouths of Upper Three Runs, Fourmile Branch and the Savannah River at the highway 301 bridge

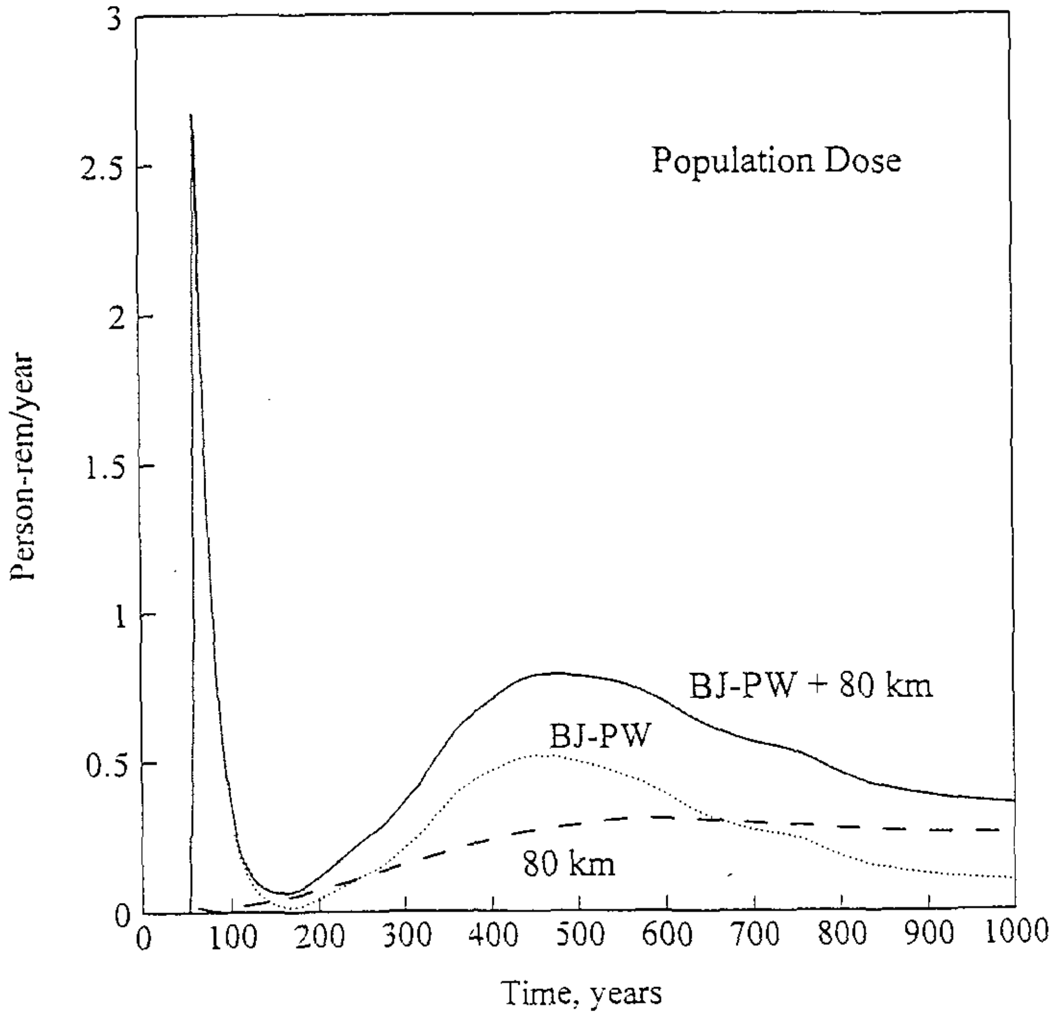

Figure 1-2. **Collective dose to the Port Wentworth, Beaufort-Jasper and 80 km (assessed at the highway 301 bridge) populations**

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2. INTRODUCTION

The SRS was acquired by the U.S. Government in 1950. Since that time, the U. S. Government has contracted for the design, development, construction, and operation of various facilities at the SRS to support national defense and space exploration. Because of these activities at the SRS, low-level, solid, non-hazardous radioactive wastes have been and will continue to be generated. In addition, Environmental Restoration (ER) and Decommissioning and Decontamination (D&D) activities will generate increasing quantities of low-level radioactive wastes.

The policies and guidelines of the DOE and other regulatory agencies require that radioactive waste be managed, treated, stored, and disposed in a manner that protects public health and safety, the environment, and groundwater resources. These practices must be done in accordance with standards specified in federal, state, and local regulations. The level of radioactivity in any effluent released to the environment should be maintained "As Low As Reasonably Achievable (ALARA)", known as the "ALARA" principle within the DOE complex.

DOE Order 5820.2A, issued in 1988 (USDOE 1988a), established policies, guidelines, and minimum requirements for the management of radioactive waste, Mixed Waste (MW), and contaminated facilities at the DOE sites. This Order addresses the storage, treatment, and disposal of HLW, MW, LLW, Transuranic (TRU) waste, and naturally occurring and accelerator-produced radioactive materials that are generated by the DOE operations. Chapter III of the Order requires the DOE field sites to prepare and maintain a site-specific radiological Performance Assessment (PA) for any LLW disposal facility located at DOE field sites. A PA must provide reasonable assurance that the facility design and method of disposal will comply with the performance objectives of the Order (Dodge et al. 1991). Two such PAs have been prepared for SRS: the *Radiological Performance Assessment for* *the Z-Area Saltstone Disposal Facility* (WSRC 1992a); and the *Radiological Performance Assessment for the E-Area Vaults Disposal Facility* (WSRC 1994).

The Composite Analysis described in this report complements these PAs, by addressing impacts associated with sources of radioactive material that may interact with the Z-Area and E-Area LLW disposal facilities. In other words, the potential overlap of plumes of contamination in groundwater or other media are considered.

2.1 PURPOSE AND SCOPE

A Composite Analysis of SRS's GSA is required by DOE in accordance with the revised Implementation Plan prepared in response to Recommendation 94-2 from the Defense Nuclear Facilities Safety Board (DNFSB) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The purpose of the Composite Analysis process is to supplement information DOE obtains from PAs or CERCLA risk assessments on the potential radiological impacts of continuing LLW disposal on the hypothetical future members of the public. The Composite Analysis does not need to be as detailed as the PA or CERCLA analyses, however. For the GSA, this analysis supplements information DOE has developed for PAs for the Z-Area and E-Area disposal facilities at the SRS (WSRC 1992a and WSRC 1994).

The Composite Analysis for the GSA addresses the potential cumulative impacts to a hypothetical future member of the public from the Z-Area and E-Area LLW disposal facilities and other sources of radioactive material in the vicinity of these facilities. Total projected dose from all sources will be compared with the DOE primary dose limit of 100 mrem per year. The ALARA concept will also be explored in terms of estimated maximum individual doses, collective doses, and alternative controls. For example, if the projected maximum individual dose is in excess of 30 mrem per year, an options analysis to identify alternatives that would reduce future doses would be explored.

2.2 DESCRIPTION OF THE GSA

The GSA study area comprises approximately 30 km^2 of the central SRS. The GSA contains major processing and waste management areas that will contain residual radioactivity after DOE operations at SRS cease. The areas are E Area, F Area, H Area, S Area, and Z Area. These areas are briefly described below.

E-Area

E-Area consists of several waste disposal facilities used for disposal of radioactive solid waste at SRS. The original facility, 643-E, is a 310,000 m^2 area used from 1952 through 1972. The 643-7E facility is contiguous to the original facility and received waste from 1969 through 1995. The 643-7E facility has an area of 480,000 m^2. Within the 643-7E facility, an area of 230,000 m^2 has been closed under the Resource Conservation and Recovery Act (RCRA). Beginning in 1994, disposal operations moved to the EAV Disposal Facility. This facility consists of several disposal and storage units: Low Activity Waste (LAW) Vaults, Intermediate Activity Waste (IAW) Vaults, Long-Lived Waste Storage Buildings, Suspect Soil Trenches, and Naval Reactor Components Disposal Area. The IAW vaults include cells specially designed for the disposal of tritiated waste.

Waste management operations at SRS have always distinguished among low activity, intermediate activity and alpha contaminated wastes. At SRS, the determination of low activity and intermediate activity wastes is made based on a radiation rate of 200 mR/hr.

Until 1965, alpha-bearing waste was buried in plastic bags and cardboard boxes in earthen trenches separate from those for other types of waste. Between 1965 and 1974 alpha-bearing waste was segregated into two categories. Waste containing less than 0.1 Ci per package was buried unencapsulated in separate trenches. Waste containing greater than 0.1 Ci per package was buried in concrete containers. If waste would not fit into prefabricated containers, it was encapsulated in concrete. Since 1974, alpha-bearing waste containing greater than 10 nCi/g has been stored on pads.

The EAV Disposal Facility currently consists of one LAW vault, one IAW vault, one Long-Lived Waste Storage Building, one set of Suspect Soil Trenches, and one Naval Reactor Component disposal area. The radiation rate of 200 mR/hr is used to determine whether waste goes to the LAW or IAW vaults. Material placed in Suspect Soil Trenches for disposal consists of soil, debris, rubble, and wood. The allowable inventory in Suspect Soil Trenches is set by Waste Acceptance Criteria (WSRC 1997) determined in part by a performance assessment (WSRC 1994).

F Area

F Area contains a number of facilities for the processing, handling, treatment and storage of radioactive material. The major facilities within F Area are the Separations Canyon, the Naval Fuels Facility, the F-Area HLW Tank Farm, and the Process Control Laboratory.

The F-Area Canyon is used to separate ^{239}Pu from irradiated target elements. Before being placed in standby mode, the Naval Fuels Facility was used to produce fuel material for nuclear Naval propulsion. The F-Area Tank Farm is used to store high level liquid waste generated from operations in the F-Area Canyon until it can be removed and transferred to H Area for further processing. The process control laboratory in F Area is used primarily to verify the operations of the SRS separations processes through chemical and radiochemical analyses.

H Area

H Area contains a number of facilities for the processing, handling, treatment and storage of radioactive material. Major facilities within H Area are the Separations Canyon, the Tritium Facility, the H-Area HLW Tank Farm, the Extended Sludge Processing (ESP) Facility, the Consolidated Incineration Facility (CIF), the Effluent Treatment Facility (ETF) and In-Tank Precipitation (ITP).

The H-Area Canyon is used to chemically separate enriched uranium, ^{237}Np and ^{238}Pu from irradiated fuel and target assemblies.

Liquid HLW, containing mostly fission products from the extraction processes, is stored in the H-Area Tank Farm.

Insoluble sludge solids in the HLW from storage tanks in both F-Area and H-Area Tank Farms are slurried for removal and subsequent processing and storage in the ESP Facility until the sludge slurry can be transferred to S Area for further treatment.

Soluble salts in the HLW from storage tanks in both F-Area and H-Area Tank Farms are dissolved in water for subsequent treatment in the In-Tank Precipitation (ITP) facility. In the ITP, the salt solution is treated to generate a HLW precipitate slurry and decontaminated salt solution. The HLW slurry is stored until it can be transferred for further treatment. The salt solution is transferred to Z Area for treatment and disposal as LLW saltstone.

The tritium facilities extract tritium from lithium-aluminum target assemblies. These facilities also recover and recycle tritium that has previously been deployed to the field.

The CIF consists of a rotary kiln incinerator, which thermally treats hazardous, radioactive, and mixed wastes.

The ETF treats dilute liquid waste from the processing facilities and storm water runoff. The resulting concentrate is sent to Z Area for treatment and disposal as LLW saltstone and the treated water is released to Fourmile Branch.

The flow of material and general processing are similar in F and H Areas. This is illustrated in Figure 2.2-1. Residual contamination will remain in the canyon buildings, the HLW Tanks, the Sand Filters and the Seepage Basins for each area.

S Area

S Area is the site of the Defense Waste Processing Facility (DWPF). This is a vitrification plant that converts liquid high level radioactive waste streams from ESP and ITP to a glass waste form. Canisters of glass are stored in S Area until they can be shipped to the Federal Repository for HLW.

Z Area

The Saltstone Processing Facility (SPF) and the Saltstone Disposal Facility (SDF) are located in Z Area. Decontaminated salt solutions from the ETF and the ITP are blended with cement, fly ash and blast furnace slag to produce saltstone grout. The saltstone grout is then pumped to concrete vaults in the SDF for disposal, where it solidifies into a stable monolith.

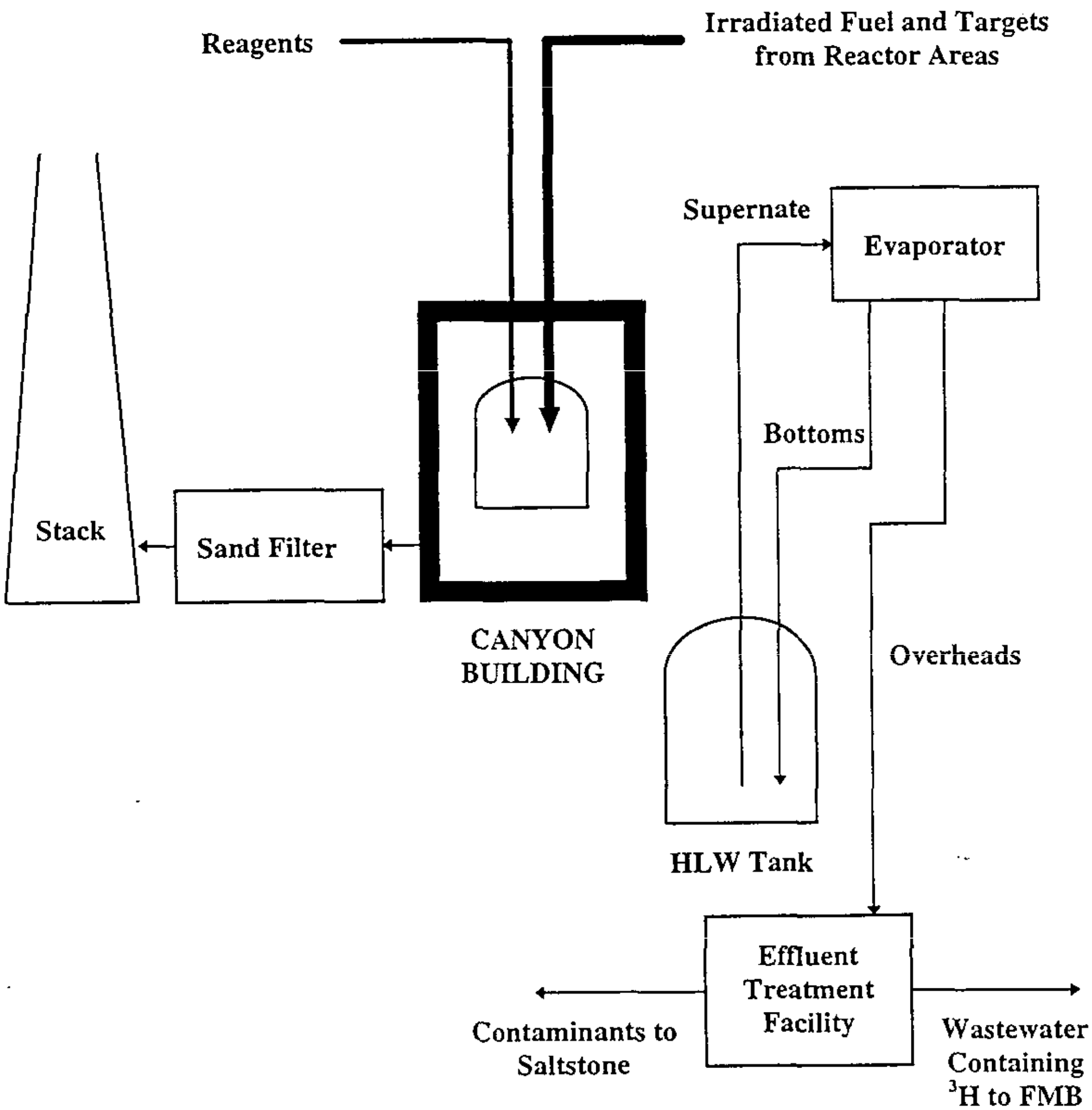

Figure 2.2-1 Separation Process Systems

2.3 REGIONAL CHARACTERISTICS

Regional characteristics must be understood to properly evaluate potential transport of, and possible exposure to, radionuclides that could be released from facilities encompassed by the GSA. The geography, demography, meteorology, seismicity, hydrogeology, quality of surface waters and groundwaters, and soils of the SRS and vicinity are briefly described in this section.

2.3.1 Geography of the Region

The SRS occupies about 780 km^2 in Aiken, Barnwell, and Allendale counties on the Upper Atlantic Coastal Plain of southwestern South Carolina (Fig. 2.3-1). The center of the SRS is about 36 km southeast of Augusta, GA; 32 km south of Aiken, SC; 160 km from the Atlantic Coast; and is bounded on the southwest by the Savannah River, for about 28 km. The Fall Line, which separates the Atlantic Coastal Plain physiographic province from the Piedmont physiographic province, is about 50 km northwest of the central SRS.

In addition to the Savannah River, other prominent geographical features within 80 km of the SRS are Thurmond Lake, Par Pond, and L-Lake. Thurmond Lake is the largest nearby public recreational area. This reservoir is on the Savannah River and is about 64 km upstream of the center of the SRS. Par Pond and L-Lake are located within the SRS (Fig. 2.3-2). Par Pond is a 11 km^2 reactor cooling water impoundment that lies in the eastern sector of the SRS. L-Lake is a 4 km^2 reactor cooling water impoundment that lies in the southern sector of the SRS.

The elevation of the SRS ranges from about 24 m above mean sea level (amsl) at the Savannah River to about 122 m amsl in the upper northwest portion of the site. The Pleistocene Coastal terraces and the Aiken Plateau form two distinct physiographic

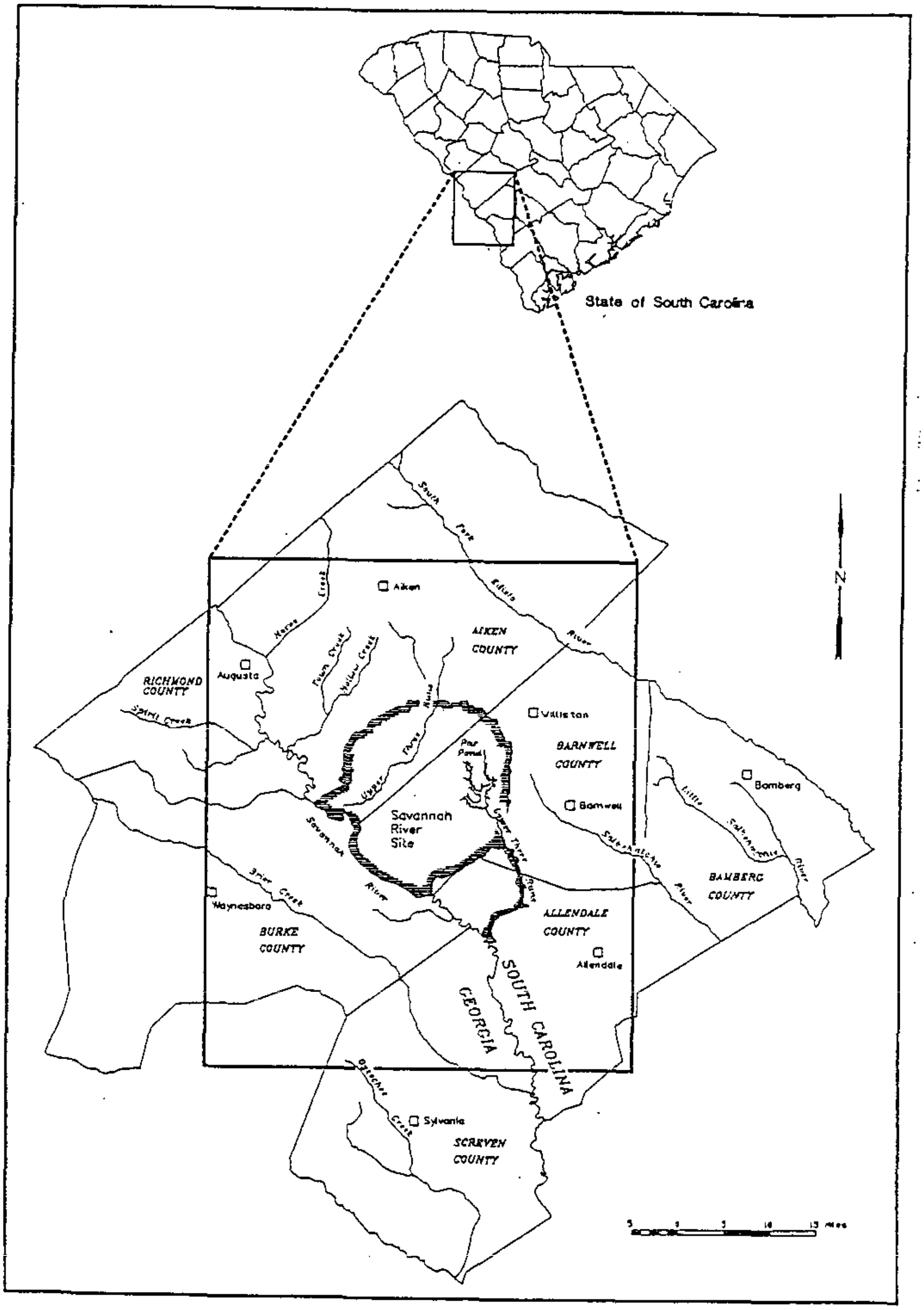

Figure 2.3-1. Location of the Savannah River Site and Adjacent Study Area

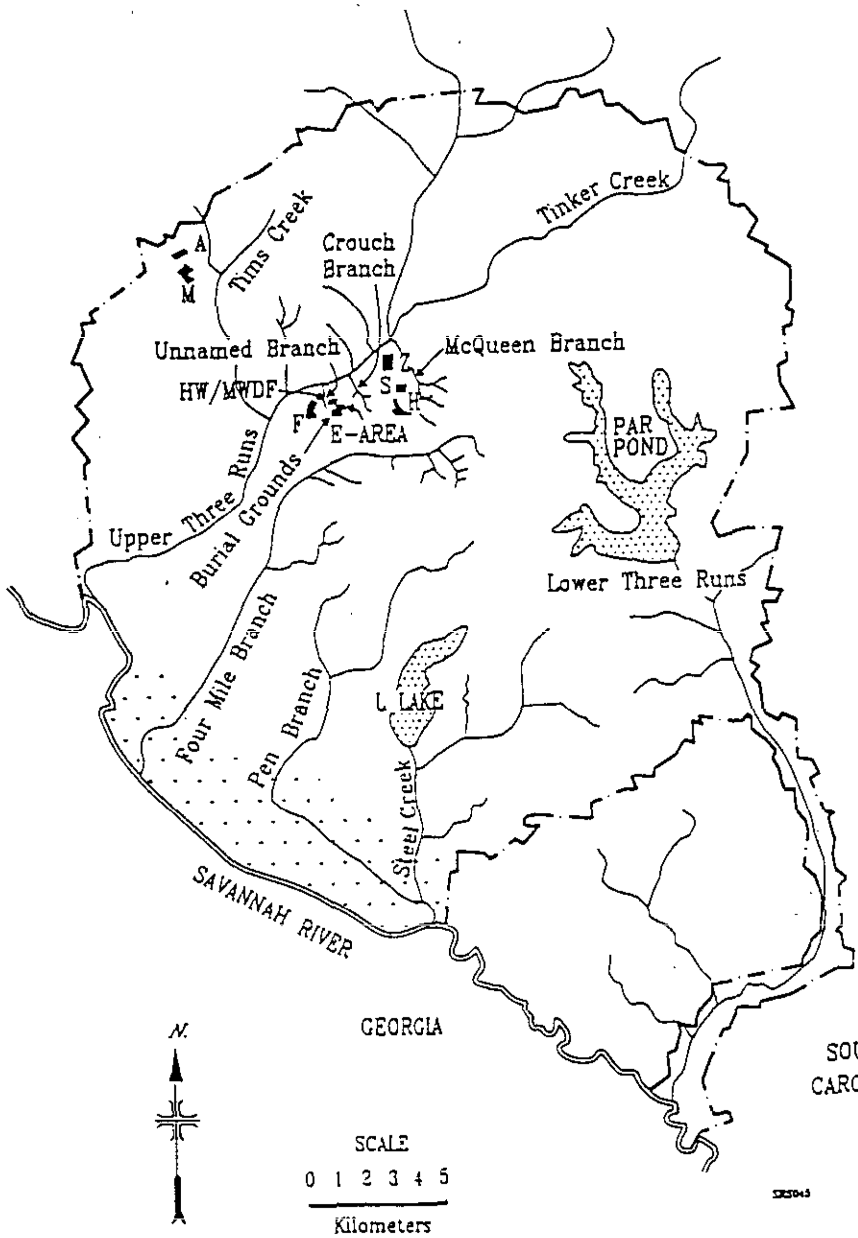

Figure 2.3-2. Facility Location Map of the SRS, Showing Surface Drainage

subregions at the SRS (WSRC 1992b). The Pleistocene Coastal terraces are below 82 m amsl in elevation, with the lowest terrace constituting the present flood plain of the Savannah River and the higher terraces characterized by gently rolling topography. The relatively flat Aiken Plateau occurs above 82 m amsl.

The Aiken Plateau is dissected by numerous streams. Because of the large number of tributaries to small streams on the SRS site, no location on the site is far from a flowing stream, most of which drain to the Savannah River.

The dominant vegetation on the SRS is forest, with types ranging from scrub oak communities on the driest areas to bald cypress and black gum in the swamps. Pine forests cover more area than any other forest type. Land use presently is about 56 percent in pine forests, 35 percent in hardwoods, 7 percent in SRS facilities and open fields, and 2 percent in water (WSRC 1992b).

Except for three roadways and a railway that are near the edge of the SRS, public access to the SRS is restricted to guided tours, controlled deer hunts, and authorized environmental studies. Figure 2.3-2 shows the major areas at the SRS and their location within the site boundary. The major production areas located at the site include: Raw Materials (M Area), Separations (F and H Areas), Waste Management Operations (E, F, and H Areas), and Defense Waste Processing (S and Z Areas) (WSRC 1992b). Administrative and support services, the Savannah River Technology Center (SRTC) and the Savannah River Ecology Laboratory are located in A-Area.

The GSA has low to moderate topographic relief and is drained by several named and unnamed perennial streams (Fig. 2.3-2). It is bordered by three streams with several intermittent streams present within the area boundary. Upper Three Runs forms the northern boundary of the GSA with an average elevation of 46 m amsl.; Fourmile Branch forms the southern boundary with an average elevation of 60 m amsl; and McQueen

Branch, which it entirely within the study area, forms the northeastern boundary with elevations falling from 76 m amsl at its head to 49 m amsl at the confluence with Upper Three Runs. There is no natural drainage at the west margin of the area. An arbitrary boundary is established west of C Road by connecting Upper Three Runs to Fourmile Branch.

2.3.2 Demography

The population within 80 km of the SRS consists of a permanent (resident) and transient population, the latter of which includes industrial, recreational, and casual components. The major residential population centers within 80 km from the approximate SRS plant center point are Augusta, Georgia, about 40 km to the northwest; Aiken, South Carolina, about 32 km to the north; and Orangeburg, South Carolina, about 79 km to the east northeast. In 1980 the estimated population within the 80 km radius around the SRS was approximately 620,000 (WSRC 1996c). More than 50 percent of the population is in the Augusta, Georgia/South Carolina Standard Metropolitan Statistical Area (SMSA) which includes Richmond and Columbia Counties in Georgia, Aiken County in South Carolina, and the Fort Gordon Military Reservation.

The growth characteristics of the cities and towns around the SRS are similar to those of the rest of the state. There is a distinct pattern of population increase in the areas just outside cities. Cities of Aiken and North Augusta, South Carolina are major urban centers with populations over 25,000. No other major urban centers are expected to develop in this area.

The transient population consists almost entirely of the SRS work force. The Fort Gordon Military Reservation, Alvin W. Vogtle Nuclear Power Plant, and Chem-Nuclear Systems have approximately 4500, 3400, and 300 employees, respectively.

2.3.3 Meteorology

The regional climate of the SRS is classified as humid subtropical, characterized by short, mild winters and long, warm and humid summers. Summer usually lasts from May through September, at which time daytime temperatures are frequently above 90°F. Winter conditions alternate between warm, moist subtropical air from the Gulf of Mexico and cool, dry polar air. Less than one-third of all winter days have a minimum temperature below freezing. Annual average precipitation, computed from daily meteorological data collected at a SRS meteorological tower from 1952 to 1992, is 124 cm/yr (Fig. 2.3-3). Extreme conditions, such as sustained winds, tornadoes, and maximum 24-hr rainfall are not expected to impact the post-closure integrity of the facilities within the GSA.

2.3.4 Geology

The surface of the Upper Atlantic Coastal Plain on which SRS is located slopes gently seaward. The province is underlain by a seaward dipping wedge of unconsolidated and semi-consolidated sediments that extends from the Fall Line to the seaward edge of the continental shelf. Sediment thickness increases from zero at the Fall Line, where the crystalline Piedmont province gives way to the Coastal Plain, to more than 1.2 km near the coast of South Carolina. The SRS is underlain by about 180 to 370 m of Coastal Plain sediments. These sediments vary in age from Late Cretaceous to Miocene, and are divided into several groups based principally on age and lithology. A brief discussion of these groups follows. An in-depth treatment of the stratigraphy of the SRS is given in a recent report by the State of South Carolina's Department of Natural Resources (Aadland et al. 1995).

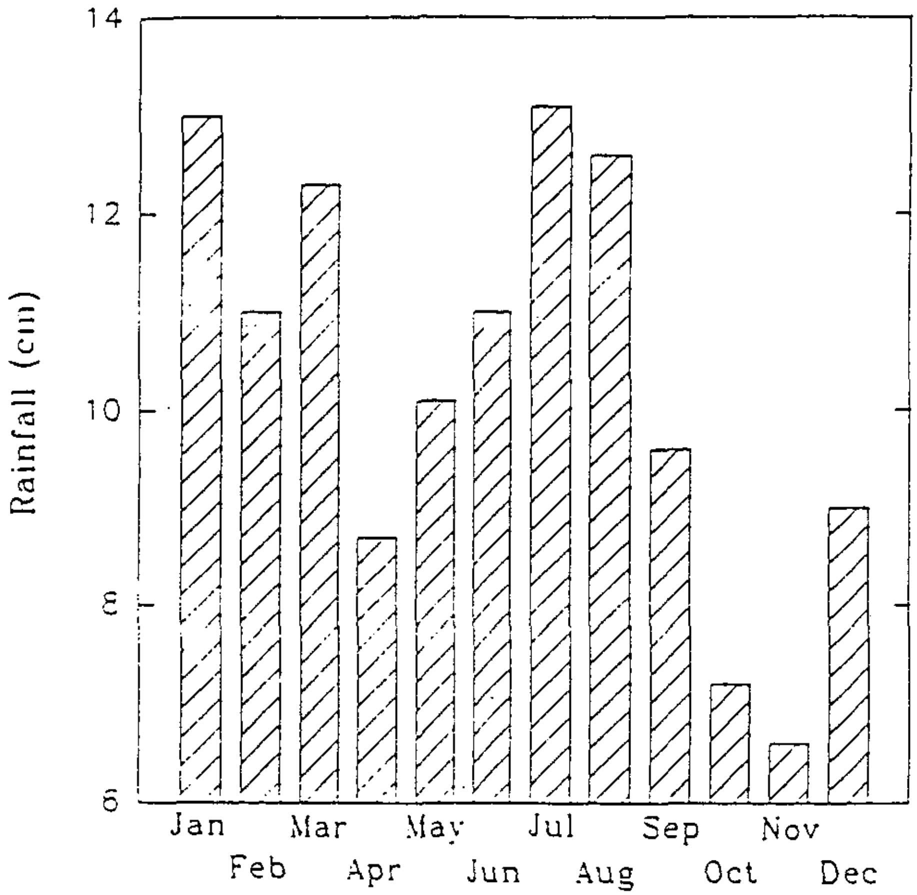

Figure 2.3-3. Average Rainfall at SRS: 1952-1992

2.3.4.1 Late Cretaceous Sediments

The Late Cretaceous sediments include, from oldest to youngest, the Cape Fear Formation and the three formations of the Lumbee Group: the Middendorf, Black Creek, and Steel Creek Formations (Fig. 2.3-4). These sediments are approximately 210 m thick at the center of the SRS.

The lowermost Cape Fear Formation rests on a thin veneer of saprolitic bedrock, which defines the surface of the crystalline and sedimentary basement rock. This formation is composed of poorly sorted silty-to-clayey quartz sands and interbedded clays. The thickness of these clay and sand beds ranges from 1.5 to 6 m, with sand beds being thicker than clay beds. The formation is about 9 m thick at the northwestern boundary of SRS, and it increases to more than 55 m near the southeastern boundary (WSRC 1992b). This formation has not been observed to outcrop in the vicinity of the SRS.

The thickness of the Lumbee Group, which overlies the Cape Fear Formation, varies across SRS from 120 m in the northwest to more than 230 m near the southeastern boundary (WSRC 1992b). The Middendorf Formation, which directly overlies the Cape Fear Formation, is composed mostly of medium and coarse quartz sand that is cleaner and less indurated than the underlying sediments. Clay casts and pebbly zones occur in several places in the Middendorf Formation. A clay zone up to 24 m thick forms the top of this formation over much of the SRS. In total, the Middendorf Formation ranges from approximately 40 to 55 m thick from the northwestern to southeastern boundary of the SRS. Outcrops of this formation have been identified northwest of the SRS.

The Black Creek Formation consists of quartz sands, silts and clays. The lower section consists of fine- to coarse-grained sands, with layers of pebbles and clay casts. The upper section changes in composition as it crosses the SRS from northwest to southeast; from massive clay to silty sand with interbeds of clay. Thickness of the Black Creek Formation

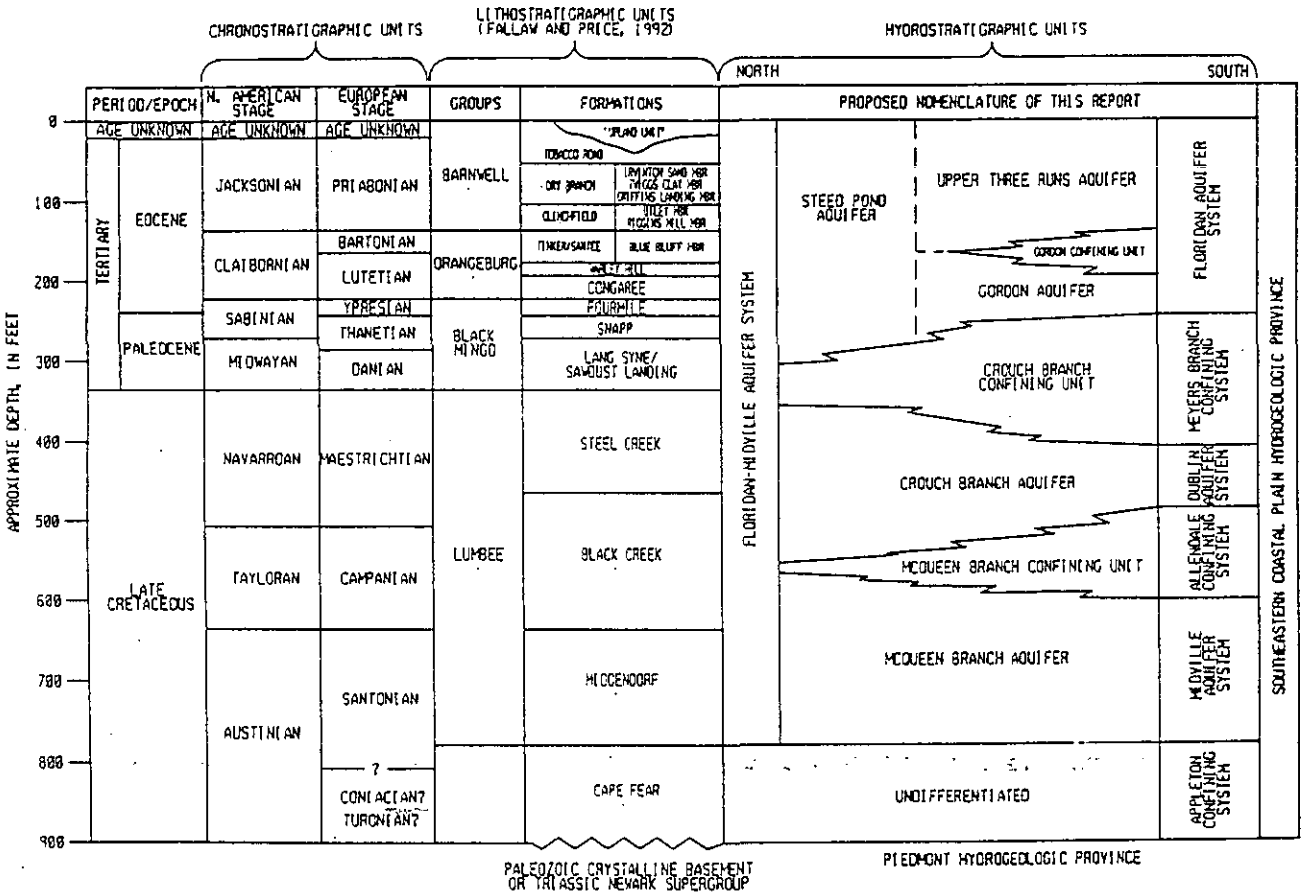

Figure 2.3-4 Comparison of Chromostratigraphic, Lithostratigraphic, and Hydrostratigraphic Units in the SRS Region

under the SRS ranges from 34 m in the northwest to 76 m in the southeast (WSRC 1992b). Outcropping in the vicinity of the SRS has not been confirmed.

The uppermost formation in the Lumbee Group is the Steel Creek Formation (previously referred to as the Pedee Formation), which consists of fine-grained sandstone and siltstone with marine fossils. This formation is comparable in age, but lithologically distinct, from the Pedee Formation in southwestern South Carolina. The lower portion of this formation consists of fine- to coarse-grained quartz sand and silty sand, with a pebble-rich zone at its base. Pebbly zones and clay casts are common throughout the lower portion of the Steel Creek Formation. The upper portion of this formation is a clay that varies from more than 15 m to less than 1 m in thickness at the SRS. The Steel Creek Formation is about 34 m thick at the northwestern SRS boundary, and about 40 m thick at the southeastern boundary (WSRC 1992b). No nearby outcropping has been identified.

2.3.4.2 Paleocene-Eocene Black Mingo Group

Paleocene-Early Eocene sediments make up the Black Mingo Group (Fig. 2.3-4). In the GSA, this group consists of the Early Paleocene Lang Syne/Sawdust Landing Formations, the Late Paleocene Snapp Formation, and the Early Eocene Fourmile Formation. This group is about 21 m thick at the northwestern SRS boundary, thickens to about 46 m near the southeastern boundary, and is about 210 m thick at the coast (WSRC 1992b).

The Lang Syne/Sawdust Landing Formations together are equivalent to the lithologic unit previously referred to as the Ellenton Formation (Siple 1967). These formations, treated as a single unit due to difficulty in mapping them separately (Aadland et al. 1995), consist mostly of gray, poorly sorted, micaceous, lignitic, silty and clayey quartz sand interbedded with gray clays. They are approximately 12 m thick at the northwestern boundary of the

SRS and thicken to about 30 m near the southeastern boundary. These formations outcrop about four miles northwest of the SRS.

The deposits near the SRS that are time equivalent to the Williamsburg Formation differ from the type Williamsburg and are designated as the Snapp Formation. The sediments are typically silty, medium- to coarse-grained quartz sand interbedded with clay. The Snapp Formation pinches out at the northwestern SRS boundary and thickens to about 15 m near the southeastern boundary. In the GSA, distribution of the Snapp Formation is sporadic, and not continuous.

Sand immediately overlying the Snapp Formation is identified as the Fourmile Formation. The well-sorted sand of this formation is an average of 9 m in thickness. Clay beds near the middle and top of the formation are a few feet thick. In the GSA, this formation may not be continuous.

2.3.4.3 Middle Eocene Orangeburg Group

The middle Eocene sediments make up the Orangeburg Group, which, in the GSA, consists of the lower middle Eocene Congaree Formation, the upper middle Eocene Warley Hill Formation, and the late middle Eocene Tinker/Santee Limestone Formation (Fig. 2.3-4). The sediments thicken from about 30 m at the northwestern SRS boundary to about 49 m near the southeastern boundary (WSRC 1992b). The dip of the upper surface of this formation is about 2 m/km to the southeast across the site. The Orangeburg Group is about 100 m thick at the coast. The group outcrops at lower elevations in many places near and on the SRS.

The Congaree Formation consists of fine to coarse, well-sorted and rounded, quartz sands. Thin clay laminae occur throughout, as do small pebble zones. The sand is glauconitic in places. The formation is about 26 m thick at the center of the SRS (Smits et al. 1997).

The Warley Hill Formation, made up of glauconitic sand and green clay beds, and thus previously referred to as the "green clay", overlies the Congaree Formation. This formation is generally 3 to 6 m in thickness. However, northwest of the GSA, the Warley Hill Formation is missing or very thin, such that the overlying Tinker/Santee Formation rests unconformably on the Congaree Formation.

The Tinker/Santee Formation consists of calcilutite, calcarenite, shelly limestone, calcareous sands and clays, and micritic limestone. The sands are glauconitic in places, and fine- to medium-grained. The sediments comprising this formation have been referred to in the past as the Santee Limestone, McBean, and Lisbon Formations, and indicate deposition in shallow marine environments. The Tinker/Santee Formation is about 12 to 15 m thick in the center of the GSA (Smits et al. 1997). In places where the Warley Hill Formation is absent, the Tinker/Santee Formation rests directly on the Congaree Formation.

2.3.4.4 Late Eocene Barnwell Group

The Late Eocene sediments make up the Barnwell Group, which consists of the Clinchfield, Dry Branch, and Tobacco Road Sand (Fig. 2.3-4). The Clinchfield Formation, the oldest of the three, is made up of quartz sand, limestone, calcareous sand and clay. It is generally identified only when the contrasting carbonates of the overlying Dry Branch and underlying Tinker/Santee Formations are present, with the sand of the Clinchfield Formation sandwiched between them. It has been identified at several areas within the SRS, where it is up to 8 m thick, but is indistinguishable in the central regions of the SRS.

The Dry Branch Formation consists of three distinguishable members: the Twiggs Clay Member, the Griffins Landing Member, and the Irwinton Sand Member. The Twiggs Clay Member cannot be mapped as a continuous unit within the SRS, but lithologically similar clay is present at various levels within this formation. The tan, light gray, and brown clay of the Twiggs Clay Member has previously been referred to as the "tan clay" at the SRS. The Griffins Landing Member is up to 15 m thick in the southeastern part of the SRS. This member consists mostly of calcilutite and calcarenite, calcareous quartz sand, and slightly calcareous clay. It occurs sporadically and pinches out in the center of the SRS. The remainder of the Dry Branch Formation within the SRS is made up of the Irwinton Sand Member, which is composed of moderately sorted quartz sand, with interlaminated clays abundant in places. Clay beds of this member have also been referred to as the "tan clay" at the SRS. The Irwinton Sand is about 12 m thick at the northwestern SRS boundary, and thickens to 21 m near the southeastern boundary. It outcrops in many places around and within the SRS.

The Tobacco Road Sand overlies the Dry Branch Formation. This formation consists of moderately to poorly sorted quartz sands, interspersed with pebble layers and clay laminae. The sediments have the characteristics of a shallow marine deposit. The upper surface of this formation is irregular due to an incision that accompanied deposition of the overlying "Upland" unit and later erosion. The thickness is variable as a result of erosive processes, but is at least 15 m in places (WSRC 1992b).

2.3.4.5 "Upland Unit"

The "Upland Unit" is an informal stratigraphic term applied to terrestrial deposits that occur at higher elevations in some places in the southwestern South Carolina Coastal Plain (Fig. 2.3-4). This unit overlies the Barnwell Group in the Upper Coastal Plain of western South Carolina, on which the SRS is located. This unit occurs at the surface at higher elevations in many places around and within the SRS, but it is not present at all higher elevations. The sediments are poorly sorted, clayey-to-silty sands, with lenses and layers of conglomerates, pebbly sands, and clays. Clay casts are abundant. The "Upland" unit is up to 21 m thick in parts of the SRS. Much of this unit corresponds to the Hawthorne

Formation and the Tertiary alluvial gravels identified in previous documents (INTERA 1986).

2.3.5 Groundwater Hydrology

A discussion of groundwater hydrology must consider all aquifers and confining units that could affect the subsurface distribution of contaminants if they were released from the GSA facilities. In this report, the discussion of groundwater hydrology is restricted to hydrostratigraphic units above the Meyers Branch confining system because units below that system are considered protected from contamination, as described in Section 2.3.5.1 below.

The nomenclature used in this report to identify hydrostratigraphic units is consistent with Aadland et al. (1995). Two different alpha-numeric systems of hydrostratigraphic nomenclature were used in the Z-Area and E-Area PAs. These systems are listed in Table 2.3-1, along with the present nomenclature. The "common" names listed in this table are names that have historically been used for the hydrostratigraphic units in many older documents on this subject. These units, and their hydrologic properties, are defined and described below.

2.3.5.1 Meyers Branch Confining System

The Meyers Branch confining system overlies the Dublin and Dublin-Midville aquifer systems (Fig. 2.3-4). Sediments of this Late Cretaceous-Paleocene system correspond to the lignitic clays and interbedded sands of the upper Steel Creek Formation, and the laminated clays and shale of the Lang Syne/Sawdust Landing and Snapp Formations. At the SRS, this confining system consists of the Crouch Branch confining unit, which is comprised of several thick and fairly continuous clay beds. East of the GSA, the Meyers Branch confining system is 41 m thick, 21 m of which is clay beds. The Crouch Branch

Table 2.3-1 Hydrostratigraphic Nomenclature

Nomenclature of Aadland et al. 1995	E-Area Nomenclature	Z-Area Nomenclature	Common Nomenclature
Floridian Aquifer System	Aquifer System II		
Upper Three Runs Aquifer			
"upper" zone	Aquifer Unit IIB, Zone 2	Zone 7c/8	Water Table Unit
"tan clay" zone	Confining Unit IIB1-IIB2	Zone 7b	Tan Clay
"lower" zone	Aquifer Unit IIB, Zone 1	Zone 6/7a	Barnwell/McBean
Gordon Confining Unit	Confining Unit IIA-IIB	Zone 5b	Green Clay
Gordon Aquifer	Aquifer Unit IIA	Zone 5a	Congaree
Meyers Branch Confining System	Confining System I-II	Zone 4	Ellenton Clays

confining unit constitutes the Meyers Branch confining system over much of the SRS, ranging in thickness from 17 m to 56 m. The updip limit of the Meyers Branch confining system, where the system no longer is a regional confining system, occurs north of the intersection of McQueen Branch and Upper Three Runs streams and runs approximately east-west. North of the updip limit, the Crouch Branch confining unit continues, and is considered part of the Floridian-Midville aquifer system (in which all aquifer units including and above the McQueen Branch aquifer are considered layered parts of one aquifer system).

Areas of the SRS which are adjacent to the Savannah River flood plain and the Upper Three Runs drainage systems exhibit an "upward" gradient across the Crouch Branch confining unit (Fig. 2.3-5). Hydraulic heads in the underlying Crouch Branch aquifer are higher than those in the overlying Gordon aquifer in these areas, because the overlying aquifer is incised by these two river systems. This area of upward gradient encompasses most of the GSA. Thus the confining nature of the Crouch Branch confining unit in the GSA and the head-reversal phenomenon naturally protect the aquifers beneath the Floridian aquifer system from contamination.

2.3.5.2 Floridian Aquifer System

Because of relative hydrologic isolation due to the Meyers Branch confining system, only the Floridian aquifer system is of interest in the Composite Analysis of potential groundwater contamination from operations at the GSA. The Floridian aquifer system is comprised of the lowermost Gordon aquifer unit, the Gordon confining unit, and the uppermost Upper Three Runs aquifer unit, which contains the water table.

Gordon Aquifer Unit. The Gordon aquifer unit overlies the Crouch Branch confining system, and is 23 m thick in the central GSA. The aquifer consists of sandy parts of the

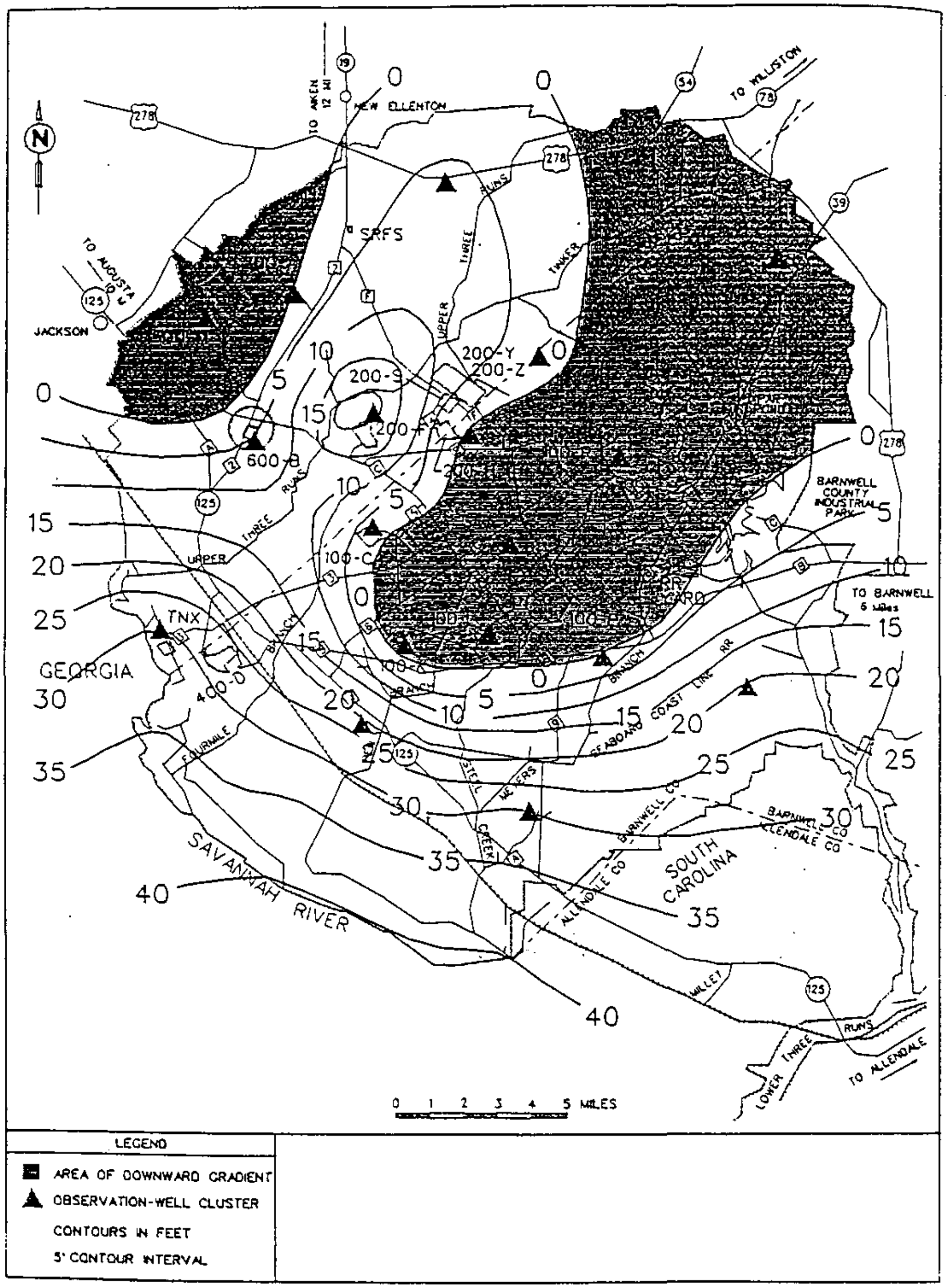

Figure 2.3-5. Hydraulic Head Difference Across the Crouch Branch Confining Unit, July 1990

Late Paleocene-Early Eocene Snapp, Fourmile, and Congaree Formations. Sands and clayey sands of the Gordon aquifer unit are largely yellow to orange in color and consist of fine- to coarse-grained, subangular to subrounded quartz. The sands range from well to poorly sorted. Locally-confining clay beds are present, as are pebbly zones. The unit dips at 1.5 to 1.7 m/km to the south and southeast and thickens in the western portion of the GSA and to a minor extent to the southeast (WSRC 1992b).

The hydraulic gradient in the Gordon aquifer across the SRS is generally from northeast to southwest, averaging 0.9 m/km, towards the Savannah River. However, the potentiometric surface indicates considerable deflection of the contours because aquifer sediments are incised by Upper Three Runs, and the flow from the GSA is westerly (Aadland et al. 1995). Potentiometric surfaces demonstrating this trend are provided in Section 5.1.1 of this report. An average horizontal hydraulic conductivity of 1×10^{-4} m/s is reported for this unit, based on measurements and modeling (Aadland et al. 1995).

Gordon Confining Unit. The Gordon confining unit separates the underlying Gordon aquifer unit from the Upper Three Runs aquifer unit. This confining unit is informally known as the "green clay". It is comprised of the fine-grained glauconitic sand and clay beds of the Middle Eocene Warley Hill Formation, and the micritic limestone of the Tinker/Santee Formation. Thickness of the Gordon confining unit in the vicinity of the SRS varies from 1.5 to 25 m. In the GSA, it is from 0.6 to 9 m thick. Recent studies indicate the unit is composed of several lenses of green and gray clay that thicken, thin, and pinch out abruptly. Extensive carbonate sediments, associated with areas of thin or truncated clay beds are present in the GSA.

Leakance coefficients, estimated from modeling and pump tests, indicate an updip limit of the Gordon confining unit at the SRS that runs southwest to northeast along Upper Three Runs and Tinker Creeks. Southeast of this limit, leakances are relatively low, except in areas associated with extensive faulting. Laboratory- and model-derived vertical hydraulic conductivities in the GSA are on the order of 5 x 10^{-10} m/s (Aadland et al. 1995), suggesting that the Gordon confining unit is an effective aquitard in this region. Horizontal hydraulic conductivities ranging from 1.4 x 10^{-10} to 1.6 x 10^{-9} m/s have been determined from laboratory tests. A map of hydraulic head differences across the Gordon confining unit (Aadland et al. 1995) shows an upward gradient (head reversal) in the vicinity of Upper Three Runs and the Savannah River. This phenomenon is caused by the overlying aquifer being incised by these two streams.

Upper Three Runs Aquifer Unit. The Upper Three Runs aquifer unit overlies the Gordon confining unit, and is the water table unit. This unit includes the sandy sediments of the Tinker/Santee Formation and all the heterogeneous sediments in the Late Eocene Barnwell Group. In the center of the SRS, the aquifer unit is 40 m thick. In the GSA, the aquifer unit is divided into three hydrostratigraphic zones with respect to hydraulic properties (Aadland et al. 1995): a "lower" zone (the water table zone), a "tan clay" locally-confining zone, and an "upper" aquifer zone.

In the GSA, the "lower" aquifer zone occurs between the overlying "tan clay" confining zone and the Gordon confining unit. It consists of sand, clayey sand, and calcareous sand of the Tinker/Santee Formation and of the lower part of the Dry Branch Formation. Groundwater that leaks across the "tan clay" confining zone recharges this zone. Most of the recharge water moves laterally toward the bounding streams which incise this zone; the remainder flows vertically downward across the Gordon confining unit. Hydraulic conductivity of the "lower" zone has been estimated for the GSA by several methods: slug tests, pumping tests, minipermeameter tests, and sieve analyses. Average values for the various methods range from 3 x 10^{-6} to 6 x 10^{-4} m/s. The lower values are based on pumping tests, and the higher values are based on sieve analyses. The large discrepancy between the two methods suggests that large-scale heterogeneities, accounted for in pumping tests, are important in determining conductivity.

The "tan clay" confining zone is a leaky confining zone, ranging in thickness from 0 to 10 m throughout the GSA. The average thickness is about 3 m. The clay beds of this confining zone, when present, generally support a head difference (up to 5 m) in the GSA between the "upper" and "lower" aquifer zones of the Upper Three Runs aquifer unit, thus indicating that the movement of water downward across this zone is retarded to some degree. Laboratory analyses of undisturbed samples of the "tan clay" confining zone yielded a range of hydraulic conductivities from 6×10^{-11} to 5×10^{-7} m/s in the horizontal direction and 1×10^{-11} to 4×10^{-7} m/s in the vertical direction (Aadland et al. 1995).

In the GSA, the "upper" aquifer zone consists of the silty sands of the Irwinton Sand Member of the Dry Branch Formation overlain by the saturated clayey sands of the Tobacco Road Formation. The water table occurs in this "upper" zone. This zone overlies the "tan clay" confining zone, when present, and the "lower" aquifer zone, when the "tan clay" confining zone is absent. Slug tests, minipermeameter tests, pumping tests, and sieve analyses have been used to estimate hydraulic conductivity of the "upper" zone in the vicinity of the GSA (Aadland et al. 1995). The average hydraulic conductivity estimates for the "upper" aquifer zone ranged from 2×10^{-6} to 5×10^{-4} m/s for the various methods.

Three streams on site, Upper Three Runs to the north of the GSA, McQueen Branch to the northeast (a tributary of Upper Three Runs), and Fourmile Branch to the south, are natural boundaries to groundwater flow in the Upper Three Runs aquifer unit. All creeks cut into this aquifer, and thus groundwater is either intercepted by the creeks or recharges the underlying Gordon aquifer unit. The influence of these streams causes a groundwater divide to occur within this water table unit.

2.3.5.3 Hydrologic Characteristics of the Vadose Zone

The vadose zone extends from the ground surface downward to the water table. Hydraulic characteristics of unsaturated soil in E-Area were investigated by Gruber (1980) and in nearby Z-Area, by Quisenberry (1985). Soil water content - soil water pressure relationships for soil in both areas were developed, as were relationships between hydraulic conductivity and water content. Saturated hydraulic conductivity of these soils was estimated by Gruber, using undisturbed soil cores, to be on the order of 1×10^{-6} m/s, with porosity on the order of 0.47 to 0.52, and bulk density on the order of 1.6 g/cm^3. Saturated hydraulic conductivity of Z-Area undisturbed soil was estimated by Quisenberry to be 2×10^{-7} m/s, with a porosity of 0.37 and corresponding bulk density of 1.7 g/cm^{-3}. Quisenberry also noted that the field measurements were made in three well-drained areas.

2.3.6 Surface Water Hydrology

The Savannah River cuts a broad valley approximately 76 m deep through the Aiken Plateau, on which most of the SRS sits. The Savannah River Swamp lies in the floodplain along the Savannah River and averages about 2.4 km wide. Upper Three Runs, Fourmile Branch, Tinker Creek, Pen Branch, Steel Creek,and Lower Three Runs (Fig. 2.3-2) are the major tributaries of the Savannah River that occur on the SRS. Three breaches of the natural levee occur at the confluences of Beaver Dam Creek, Fourmile Branch and Steel Creek with the Savannah River, allowing discharge of these streams to the river. During swamp flooding, water from Beaver Dam Creek and Fourmile Branch flows through the swamp that parallels the river and combines with the Pen Branch flow. Pen Branch joins Steel Creek about 0.8 km above its mouth.

Surface water is held in artificial impoundments and natural wetlands on the Aiken Plateau. Par Pond, the largest impoundment on the SRS, is located in the eastern part of the SRS, covering about 11 km^2. A second impoundment, L Lake, lies in the southern portion of SRS and covers approximately 4 km^2. The waters drain from Par Pond and L Lake to the south, via Lower Three Runs and Steel Creek, respectively, into the Savannah River. Lowland and upland marshes, and natural and man-made basins on the SRS retain water intermittently.

Near the SRS, the flow of the Savannah River has been stabilized by the construction of upstream reservoirs. The yearly average flow is approximately 300 m^3/s (10,500 cfs) at the point where Highway 301 crosses the river approximately 20 km downstream of the site (Hayes and Marter 1991). The minimum average annual flow rate at this location, which occurred in 1988 based on data collected from 1954 to 1988, was 150 m^3/s (5,200 cfs). From the SRS, river water usually reaches the coast in five to six days, but may take as few as three days. At the Beaufort-Jasper and Port Wentworth water treatment plants, both approximately 160 km downstream of the site, the average annual flow rate is estimated to be approximately 370 m^3/s (13,000 cfs) (Hayes and Marter 1991).

The watershed of Upper Three Runs drains about 500 km^2 of the Upper Coastal Plain northeast of the Savannah River. Significant tributaries to this creek are Tinker Creek, which is a headwaters branch that comes in northeast of the GSA, and Tims Branch, which connects west of the GSA (Fig. 2.3-2). There are no lakes or flow control structures on Upper Three Runs or its tributaries on the SRS. The stream channel has a low gradient and is meandering. Its floodplain ranges in width from 0.4 to 1.6 km and is heavily forested with hardwoods.

Upper Three Runs is gauged by the U. S. Geological Survey (USGS) about 5 km above the confluence with the Savannah River, near Road A (USGS 1997a). This location is of interest in this analysis, because it is just west of the GSA and thus is a point through which any radionuclides must pass, if they are discharged with the groundwater into Upper Three Runs or any of its tributaries in the GSA. The average annual flow at this location, as measured by the USGS between 1987 and 1996, was approximately 6.1 m^3/s (217 cfs)

(USGS 1997a). During the driest of the four years of measurement, the average flow was 3.6 m^3/s (127 cfs), and during the wettest, 6.5 m^3/s (228 cfs). These flow rates reflect contributions of upstream tributaries, including McQueen Branch and other tributaries and unnamed creeks that receive groundwater discharges from the GSA.

Fourmile Branch has been gauged in the vicinity of the confluence with the Savannah River (USGS 1997b), approximately 6 km upstream of this point. Data collected at this gauging station for nine years (between 1987 through 1996) were analyzed. These data indicate an average annual flow of 0.68 m^3/s (24 cfs) at this location. A minimum annual average flow rate, in 1994, of approximately 0.40 m^3/s (14 cfs) was measured during the gauging period. A maximum average flow rate during these nine years of 0.91 m^3/s (32 cfs) occurred in 1992.

2.3.7 Water Quality and Usage

2.3.7.1 Groundwater

The sand beds that comprise the Midville aquifer system (Fig. 2.3-4) are an important source of water for wells in localities neighboring the SRS. Most municipal and industrial water supplies in Aiken County, South Carolina are developed in the Midville aquifer system, which underlies the Allendale confining system and is beneath the sediments of potential concern in the Composite Analysis. In Barnwell and Allendale counties, some municipal users are supplied from the shallower Floridian aquifer system (Gordon and Upper Three Runs aquifers). Private domestic supplies in all of these counties are primarily obtained from the Midville aquifer system.

Municipal and industrial groundwater use in the vicinity of the SRS indicated total pumpage from the Midville aquifer system on the order of 1 m^3/s; 0.2 m^3/s from the

Gordon aquifer; and up to 0.04 m^3/s from the Upper Three Runs aquifer. The SRS uses up to 0.4 m^3/s on site, from the Midville aquifer system (Cook et al. 1987).

2.3.7.2 Surface Water

Water from the Savannah River is used for drinking water at two locations below the SRS. About 160 km downstream of SRS, The Beaufort-Jasper Water Treatment Plant at Hardeeville, SC, withdraws about 0.3 m^3/s for a consumer population of approximately 60,000. The Cherokee Hill Water Plant at Port Wentworth, GA, about 180 km downstream of the SRS, presently withdraws about 2 m^3/s for industrial use and a consumer population of about 10,000. The Savannah River is also used for commercial and sport fishing and for recreational boating. Surface water quality is presently monitored by the Environmental Monitoring Section and the Savannah River Technology Center at the SRS (Cummins et al. 1990). Surface water is characterized with respect to radiological and non-radiological aspects, both on site and downstream of the SRS.

2.3.8 Soils

Most of the soils at the SRS are sandy over a loamy or clayey subsoil. The distribution of soil types is very much influenced by the creeks on the site, with colluvial deposits on hill-tops and hillsides giving way to alluvium in valley bottoms (Dennehy et al. 1989). Road cuts and excavations on interstream areas near the SRS commonly expose a deeply developed soil profile. Two horizons are apparent: the A horizon may be up to 3 m thick, and typically consist of structureless fine- to medium-grained quartz sand, and the lower B horizon, which may be from 0.6 to 3 m in thickness, contains iron and aluminum compounds leached from the overlying material.

Weathering effects are evident. In some areas, intense weathering has produced tensional soil fractures as a result of volume reduction. These fractures are dominant features in shallow exposures such as drainage ditches or roadside embankments. Average soil erosion rates for the area surrounding the SRS, much of which is cropland, range from 1.5 to 2.0 kg/m^2-yr. (USDA 1985). Employing the Universal Soil Loss Equation to predict erosion at the SRS under different vegetative conditions, Horton and Wilhite (1978) estimate that the presence of natural successional forests would reduce erosion by a factor of 400 to 500 over cropland erosion.

2.3.9 Ecology

2.3.9.1 Aquatic Ecology

Flora in the Savannah River basin and in creeks on the SRS site is diverse and seasonally variable. Several species of diatoms, green algae, yellow-green algae, and blue-green algae are present. In seasonally flooded areas, bald cypress and tupelo gum thrive. In less severely flooded areas, oak, maple, ash, sweet gum, ironwood, and other species, less tolerant of flooding, are found. In the river swamp formed by the Savannah River in the vicinity of the SRS, herbaceous growth is sparse. A number of macrophytes, such as cattail and milfoil, are found in areas receiving sufficient sunlight.

The fish communities in the Savannah River and in creeks on the SRS are very diverse. Redbreast sunfish, spotted sucker, channel catfish, and flat bullhead are the dominant species. Sunfish, crappies, darters, minnows, American shad, and striped bass are also abundant.

Macroinvertebrate communities are largely comprised of true flies, mayflies, caddisflies, stoneflies, and beetles. Leaf litter input is high, but is rapidly broken down by macroinvertebrate shredders. The Asiatic clam is found in the Savannah River and its larger tributary streams.

2.3.9.2 Terrestrial Ecology

Prior to its acquisition by the U. S. Government in 1950, approximately one-third of the SRS was cropland, about half was forested, and the remainder was floodplain and swamp. Since that time, the U. S. Forest Service has reclaimed many previously disturbed areas through natural plant succession or by planting pine trees. As was noted in Section 2.3.1, 91 percent is now pine or hardwood forests, with the remaining 9 percent divided between SRS facilities and water bodies.

A variety of vascular plants exist on the site. Scrub oak communities cover the drier sandy areas, which includes predominantly longleaf pine, turkey oak, bluejack oak, blackjack oak, dwarf post oak, three awn grass, and huckleberry (USDOE 1987). On the more fertile, dry uplands, white oak, post oak, southern red oak, mockernut hickory, pignut hickory, and loblolly pine predominate, with an understory of sparkleberry, holly, greenbriar, and poison ivy. Pine trees cover more area than any other tree genus.

The heterogeneity of the vegetation on the SRS supports a diverse wildlife population. Several species of reptiles and amphibians are present due to the variety of aquatic and terrestrial habitats. These include snakes, frogs, toads, salamanders, turtles, lizards, and alligators. More than 213 species of birds have been identified on the SRS. Burrowing animals at the SRS include: Peromyscus polionotus, known commonly as the Old Field Mouse; Blarine brevicauda, known as the Short Tail Shrew; Scalopus aquiticus, known as the Eastern Mole; Pogonomyrmex badius, known as the Harvester Ant; Dorymyrmex pyramicus, known as the Pyramid Ant; and earthworms (Briese and Smith 1974; Davenport 1964; Golley and Gentry 1964; Smith 1971; Van Pelt 1966).

2.4 DOSE OBJECTIVES

According to DOE's guidance for composite analyses (USDOE 1996) "The Composite Analysis will estimate the potential cumulative impacts to a hypothetical future member of the public from the active or planned LLW disposal facility and other sources of radioactive material in the ground that may interact with the LLW disposal facility ...." Estimation of these potential impacts requires that the geographic location(s) of the impacts (point(s) of assessment), and the time period over which potential impacts must be considered, be specified. These issues are discussed in this section. The dose limits and constraints with which potential impacts should be compared, according to the guidance, are also presented in this section.

2.4.1 Points of Assessment

The points of assessment for the composite analysis are the geographic locations that hypothetical future members of the public (both individuals and populations are considered) can reasonably be expected to access, taking into consideration any natural barriers and land use planning for the SRS and vicinity. Two media could be contaminated by radionuclides contained in facilities located in the GSA: groundwater and surface water which is recharged by groundwater. Contamination of the ground surface is not expected, and thus air and soil are not routes of potential contaminant transport. A more in-depth discussion of transport pathways is provided in Section 4.3.

Upper Three Runs (UTR) and Fourmile Branch (FMB) form the northern and southern boundaries of the GSA (Figure 2.3-2). Both of these streams remain on site until they reach the Savannah River. Both of the streams cut into the uppermost aquifer subject to contamination from the GSA (Section 2.3.5). UTR also cuts into the Gordon aquifer, which is the lowermost of the two aquifers subject to contamination from the GSA. FMB is upgradient with respect to the GSA for the Gordon aquifer. The Gordon aquifer flows northwestward under FMB towards UTR. Thus, these streams will intercept all plumes of groundwater contamination emanating from the GSA. Land-use planning for the SRS (Appendix A) indicates that release of the site to the public for unrestricted use will not occur over the time period of this analysis; therefore, on-site use by the public of potentially-contaminated groundwater is not a reasonable expectation.

Contaminated surface water is considered a potential source of exposure to a hypothetical future member of the public in this analysis. All contaminated groundwater will discharge to streams which bound the GSA. While land-use plans are expected to restrict use of the SRS during the time period of the analysis, the confluence of on-site streams with the Savannah River poses a potential means of public access to contaminated environmental media. Thus, the points of assessment for this analysis are the mouths of UTR and FMB and the Savannah River.

Even though land-use planning envisions the continual control of the Savannah River Site, consistent with current boundaries, it is conceivable that a member of the public could gain access to the mouths of Four Mile Branch and Upper Three Runs creek by boat from the Savannah River. Thus, the mouths of UTR and FMB, at the furthest downstream point where creek water remains undiluted with Savannah River water, are points for the assessment of potential dose to a hypothetical future member of the public.

Additionally, the Savannah River will continue to be a point of public access. To be consistent with the SRS annual environmental monitoring public report (WSRC, 1996c), this composite analysis evaluates the dose to a hypothetical future member of the public at the highway 301 bridge, 20 km downstream of the SRS.

Concentrations of radioactive material at the mouths of UTR and FMB will potentially include contributions from sources outside the GSA. At the highway-301 bridge, all sources of residual radioactive material on the SRS could potentially contribute to calculated dose. The composite analysis, however, has only considered the sources within the GSA because it is those sources that could influence decisions regarding operations of the LLW disposal facilities.

Two other locations were selected to assess the sensitivity of the composite analysis to future land use decisions. These locations are on Upper Three Runs and Four Mile Branch, just downstream of the recharge points from groundwater passing under the GSA. These locations were selected because they represent points at which maximum surface water concentrations are expected to occur.

For the assessment of potential collective dose to future populations, the population within an 80-km radius of the center of the SRS is assumed to participate in recreational activities at the highway 301-bridge location on the Savannah River. Two additional locations on the Savannah River are also used: 1) 160 km downstream of the SRS at the Beaufort-Jasper, SC water treatment plant; and 2) 160 km downstream of the SRS at the Port Wentworth, GA water treatment plant. These locations were selected because they represent present populations considered in the SRS annual environmental monitoring public report (WSRC, 1996c).

The points of assessment, as well as the scenarios analyzed are summarized in Table 2.4-1. Development of exposure scenarios is discussed in Section 5.4.

2.4.2 Time of Assessment

Consistent with DOE's Composite Analysis guidance document (USDOE 1996c), the Composite Analysis for the SRS GSA considers maximum doses that may potentially be received by a hypothetical future member of the public within a time period of at least 1,000 years. For long-lived and strongly-sorbing radionuclides, the actual peak dose may occur at times beyond 1,000 years due to slow transit times in soil and groundwater. For these radionuclides, a dose at 1,000 years is estimated, along with a peak dose and the time of occurrence of the peak dose.

Table 2.4-1 Points of Assessment and Scenarios Analyzed

Hypothetical Future Public Individual		
Base Cases		
Point of Assessment	Scenario	Flow Rate
UTR Creek Mouth	Recreation	Average
FMB Creek Mouth	Recreation	Average
SR 301-Bridge	Recreation + drinking water	Average
Sensitivity Cases		
Point of Assessment	Scenario	Flow Rate
UTR Creek Mouth	Recreation	Max. & Min.
FMB Creek Mouth	Recreation	Max. & Min.
UTR Creek at GSA	Drinking water	Average
FMB Creek at GSA	Drinking water	Average
Hypothetical Future Public Population		
Base Cases		
Point of Assessment	Scenario	Flow Rate
SR 301-Bridge (80-km population)	Recreation	Average
Beaufort-Jasper & Port Wentworth	Drinking water	Average

2.4.3 Primary Dose Limits and Dose Constraints

The dose limits and constraints pertinent to composite analyses are those that are consistent with the DOE's requirements for radiological protection of the public and the environment, as set forth in DOE Order 5400.5 (USDOE 1990). From DOE Order 5400.5, a primary dose limit of 100 mrem per year is established, considering all potential pathways of exposure and all sources. This dose limit is applicable to the Composite Analysis. If doses are estimated to exceed 100 mrem per year, at the designated point of assessment and within the time period of the assessment, an options analysis is required, in which alternatives are identified for reducing future doses to levels below the primary dose limit.

In addition to the primary dose limit of 100 mrem/yr, a dose constraint of 30 mrem/yr is identified (USDOE 1996b). This constraint represents a "significant fraction of the (primary dose) limit" beyond which an options analysis is also required, "to ensure that no single source, practice, or pathway uses an extraordinary portion of the primary dose limit".

An ALARA analysis is also required under DOE Order 5400.5. The term ALARA represents a principle whereby radiation doses should be kept "as low as reasonably achievable". According to DOE Order 5400.5, implementation of the ALARA process should consider maximum individual doses, collective doses, and alternative treatments or controls and the associated doses, costs, and other changes in impact. Because quantitative optimization is difficult and expensive, qualitative analyses are considered acceptable in some cases, "especially where potential doses are well below the dose limit" (USDOE 1990).

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3. DATA QUALITY OBJECTIVES

The Composite Analysis necessitates collection and compilation of technical information from the various facilities located within the GSA to create a residual radionuclide inventory estimate. This estimate is used to develop the source term (Section 4.0) and thus is critical to the estimate of dose. The Data Quality Objectives (DQOs) Process, developed by the U. S. EPA (USEPA 1994), was applied to development of the inventory estimates and is outlined below. Following completion of the DQO Process, a Data Quality Assessment (DQA) was performed to evaluate the results of the DQO Process. The DQA is discussed in Section 3.3.

3.1 Background

The DQO Process is a planning tool for data collection whereby qualitative and quantitative statements are derived which specify the study objectives, domain, limitations, and the appropriate type of data to collect. The goals of the DQO Process are to ensure that data collection will provide sufficient data to make required decisions with reasonable certainty, and to minimize the amount of data to be collected. While generally applied to development of statistical sampling methods, the DQO Process was used as guidance for development of a plan for collecting and analyzing preexisting radionuclide inventory data for the Composite Analysis.

3.2 DQO Development

The goal of this investigation is to gather residual radiological data for facilities at the SRS that are located within the hydrologic regime between Upper Three Runs and Fourmile Branch (the GSA). Application of the DQO Process in achieving this goal requires that the questions to be answered be formulated very specifically and that the degree of confidence in the data be specified. These requirements are addressed in the following sections to the extent that they are applicable, according to the seven steps outlined in the DQO Process (USEPA 1994).

3.2.1 Step 1: State the Problem

Many types of radiological materials have been processed, treated, stored, or disposed of at facilities at the SRS. Upon future closure of these facilities there will possibly be residual radionuclides remaining within the closed facilities, soil and/or groundwater. In order to estimate potential dose for the Composite Analysis, the potential residual radionuclide inventory must be identified.

Available resources for the residual inventory data required in support of this analysis include:

- Peer-reviewed technical reports
- Shipping and disposal records/facility inventories
- Process modeling
- Plant operating records
- Process knowledge
- Waste stream forecasts
- Interviews with plant personnel.

The DQO Process requires, as part of this step, identification of individuals involved in planning the particular application of the DQO Process. For the radionuclide inventory development task, this DQO Planning Team included a QA specialist, computer modeler, task manager, and the Composite Analysis technical lead. The technical lead is the primary decision maker for the DQO Process.

3.2.2 Step 2: Identify the Decision

The decision to be made in this application of the DQO Process is whether the resources available will provide a reasonably representative residual inventory upon which dose estimates for the Composite Analysis can be based. Unacceptable data quality or quantity will lead to unreliable estimates of dose. Carefully analyzed and reviewed data from multiple sources will lead to the best estimate of dose, which is the goal of the Composite Analysis.

3.2.3 Step 3: Identify Inputs to the Decision

An indexed list of references for all facilities within the GSA, with associated potential radionuclides, was developed. This list was presented in a Radionuclide Inventory Information Report (CDM 1997). The Composite Analysis includes a review of the residual radionuclide information from these various facilities located within the GSA to create the residual radionuclide inventory estimate. The residual radionuclide information for each source used in the composite analysis is presented in Section 4.

The available information included inventory estimates based on process knowledge and assumptions, facility inventories, and various records. The contaminants of concern include residual radionuclides that have been stored, processed and/or disposed of at a facility or specific location within the GSA. All estimates and assumptions were provided by the WSRC technical staff most familiar with the facility operations. Members of this Data Resource Team are listed in Table 3.2-1. Inventory estimates were documented and approved by the WSRC Composite Analysis Task Team.

Table 3.2-1. Data Resource Team

Data Team Member	Area of Responsibility/Expertise
Tom Butcher	Composite Analysis Task Team
Jim Cook	Composite Analysis Task Team
Cliff Cole	RCRA/CERCLA Sites
Paul d'Entremont	F- and H-Area Tank Farms
John Fowler	Saltstone Vaults
Bob Hester	F- and H-Area Tank Farms
Heather Holmes	E-Area Vaults
Bob Hsu	Tritium Facilities
David Isiminger	Site Control Maps
Ray Lux	F- and H-Area Separations Facilities
Don Morris	Environmental Protection Department
Charles Murphy	RCRA/CERCLA Sites
Greg Peterson	Environmental Protection Department
Albert Poon	F- and H-Area Separations Facilities
Don Purcell	LAW Vaults
Bill Sadler	RCRA/CERCLA Sites
Joe Shappell	Hazardous Waste Facilities
Don Sink	ILV and E-Area Trenches
Don Morris	Environmental Protection Department
Greg Peterson	Environmental Protection Department
David Isiminger	Site Control Maps
Joe Shappell	Hazardous Waste Facilities
Don Sink	ILV and E-Area Trenches
Don Purcell	LAW Vault

3.2.4 Step 4: Define the Study Boundaries

Spatial Boundaries

The geographic domain of interest covers areas in which residual radionuclides may be present that may contribute to contaminant plumes potentially emanating from the Z-Area and E-Area disposal facilities. These areas are present in the GSA of the SRS, which is bounded to the northwest by Upper Three Runs and to the southeast by Fourmile Branch.

The population of interest are those facilities or specific locations within the GSA that have in the past, or will have potentially in the future, processed, handled, stored, or disposed of radioactive materials. This includes facilities such as burial grounds, processing facilities, and storage buildings. Also included are known spills or releases of radioactive material within the GSA. The Data Resource Team (Section 3.2.3) was responsible for determining if estimates were required for individual facilities or if several facilities could be grouped together to form an individual data point.

Temporal Boundaries

The Composite Analysis is based on both estimated past and potential future residual radioactive material in the GSA. Radionuclides have been processed at the SRS since 1950 and the Composite Analysis projects forward for the next 1000 years.

All historical data were gathered during the last quarter of 1996 and the first quarter of 1997. Predicted future releases are based on information derived from analysis of historical trends and process knowledge that was available as of the first quarter of 1997.

Practical Constraints on Data Collection

Due to the projected Composite Analysis completion date of September 1997, no data provided after first quarter of 1997 were used in this Composite Analysis. No new field or analytical data were collected to define the residual radionuclide inventory. There is no way to statistically validate the historical records; rather, many different sources of data were exploited to limit uncertainty.

3.2.5 Step 5: Develop a Decision Rule

The scope of the Composite Analysis is confined to residual radionuclide inventories and releases. Releases that contain no radioactive contaminants were not considered.

The decision rule developed for this application of the DQO Process can be stated as: "If the radionuclide inventories identified for facilities and specific locations in the domain of interest are reviewed and deemed representative by personnel knowledgeable about waste streams and pertinent activities leading to residual radionuclides, then the inventories will be assumed to be appropriate for the Composite Analysis. If information is unavailable or inadequate for a given facility, then the inventory will be considered incomplete, and the Composite Analysis will not be considered comprehensive.

3.2.6 Step 6: Specify Limits on Decision Errors

No new data was generated for this task; only historical data and/or estimates of future residual radionuclides were developed from existing information. Therefore, no statistical evaluation of the data was performed. In lieu of this, all known sources of historical and forecasting information were explored, and experts were assembled (Sect. 3.2.3) to develop and review data available. There was no exclusion of data during the initial evaluation.

Although a statistical analysis was not carried out, and confidence limits were not established, decision error was controlled through careful development, review, and evaluation of data by qualified personnel. Residual radionuclide estimates for each facility were entered on forms and each form was subjected to a QC review. There was no form of Quality Assurance/Quality Control (QA/QC) error detection calculations performed apart from a 100 percent check of the data to ensure correct data transcription and a 100 percent check of unit conversion formulas necessary to convert data to total Curies.

3.2.7 Step 7: Optimize the Design

Two general data collection design alternatives were identified for achieving the DQOs of the Composite Analysis. First, review of all sources of reported residual radionuclide concentrations or inventories for all facilities within the GSA can be accomplished. If no documented or estimated values are gathered during the data collection process for a particular facility, knowledgeable personnel should be consulted to ensure complete coverage.

An alternative design would include field collection of soils at given facilities for radionuclide analyses. This would provide actual analytical data. However, the number of samples required in addition to the time and cost for sampling and analysis would be prohibitive for this initial characterization. Also, there would be no way of analyzing soils for future contamination.

After consideration of these two alternatives, a program of collecting historical residual radionuclide data for the GSA was identified as the most effective and timely method for compiling the initial inventory for the Composite Analysis.

The flow diagram for the collection process is shown in Fig. 3.2-1. All of the residual radiological data available for each facility within the GSA were collected. The data were then analyzed to ensure that estimates were provided for all facilities identified and that their respective radionuclides were included in the Radionuclide Inventory Information Report. If a facility or radionuclide had either no data or conflicting values, then the WSRC Composite Analysis Team was called upon for resolution. The information was compiled, converted to total curies, transferred to data input forms, and subsequently to compilation tables to be utilized by the Composite Analysis modelers. Copies of relevant sections from each document received and the records of communication with the technical staff were maintained for each facility in the GSA that was part of this study.

3.3 DATA QUALITY ASSESSMENT

Data Quality Assessment (DQA) is a process of statistical and scientific evaluation that is used to assess the validity and performance of the data collection design and statistical test, and to establish whether a data set is adequate for its intended use.

3.3.1 Data Quality Indicators

There are five quality indicators that should be addressed in any DQO process. Each of the five are defined below based on the DQO Development Process in Section 3.2.0.

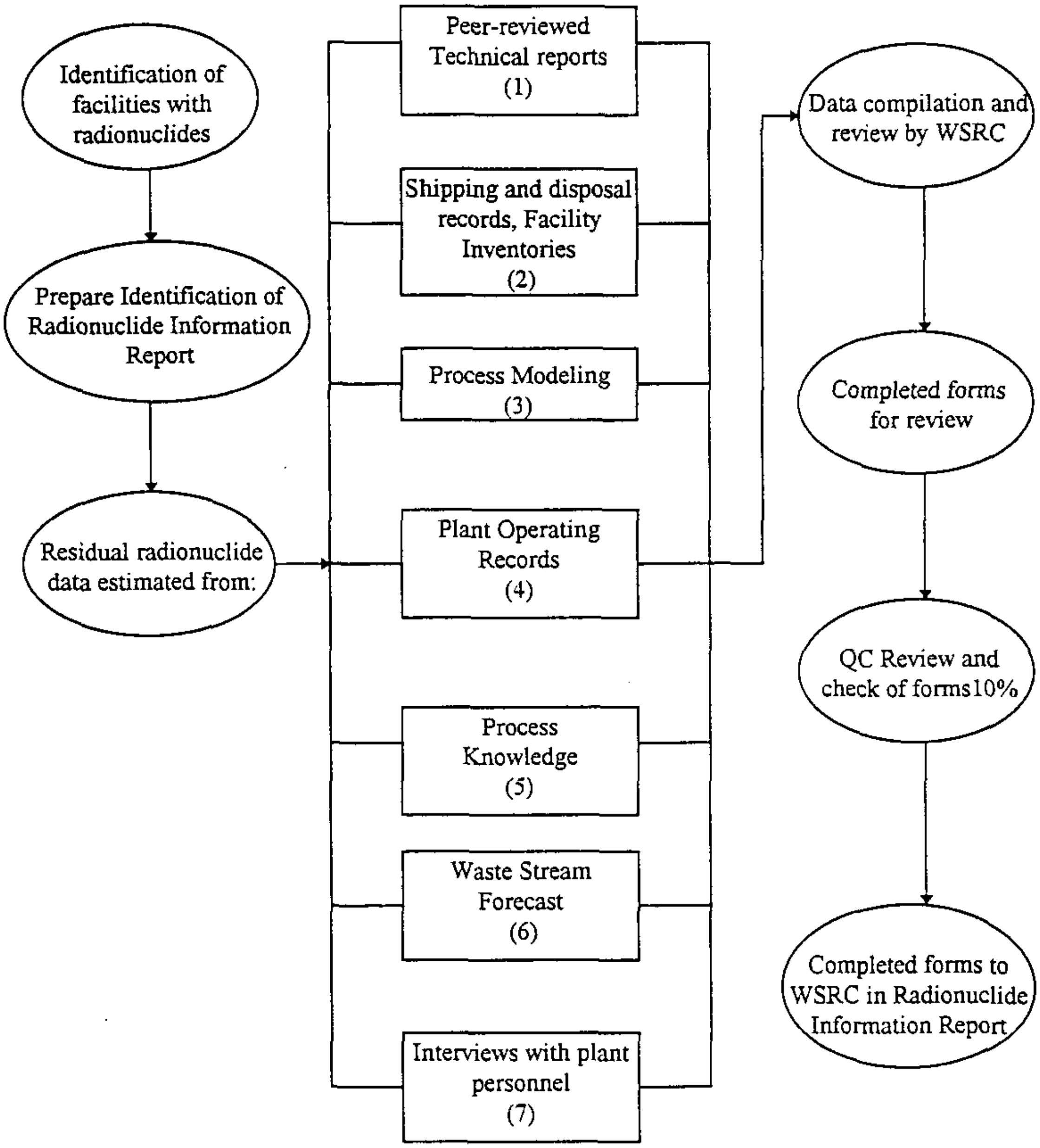

Figure 3.2.1 Flow Diagram of the Residual Radionuclide Data Collection Process

Representativeness

Representativeness is the degree to which data accurately and precisely represent the true value of the characteristics of a population, parameter variation at a sampling point, a process condition, or an environmental condition. Historical data pertinent to radionuclide inventories have some deficiencies due to the incompleteness of records or lack of knowledge; thus, representativeness may be compromised. Because more recent knowledge of past practices and radionuclide inventories allows a more complete, and thus more representative, picture of actual inventories, appropriate personnel with such knowledge were engaged to review and supplement the inventories derived for each facility.

Accuracy

Accuracy of data collected was addressed by comparing process knowledge to reported concentrations/inventories when knowledge and data permitted. In general, the degree of accuracy of much of the historical data has not been established. Accuracy of data tabulation was established by initiating a 100 percent check of the completed data entry forms for proper data transcription and a 100 percent check of the calculations used to convert reported residual radionuclide information into total curies.

Comparability

The comparability of data available from more than one source was addressed only in so far as discrepancies were used to signal potential errors. Knowledgeable experts were consulted in the case of discrepancies. In general, multiple sources of data were not available and comparisons could not be made.

Completeness

A data resource team was assembled to improve the likelihood that data collection was exhaustive of available information. This team provided a review of data, and made recommendations on exclusion of data known to be invalid. However, no extensive data validation procedure has been implemented to date. Following data collection, a further check on completeness was accomplished by ensuring that estimated or actual residual radionuclide data for all facilities identified in the Radionuclide Inventory Information Report (CDM 1997) were received, documented, and cataloged.

Precision

Precision is normally determined as part of the statistical analysis process. Specific limits for precision are not available for collecting historical data. However, appropriate experts were consulted to improve confidence that estimates were reasonable and comprehensive.

3.3.2 Data Qualification

All residual radiological data were assigned a quantitative number from 1 to 7 based on the source of information. Figure 3.2-1 is a flow diagram that lists all of the sources of data encountered along with their respective assigned number. These numerical codes classify the information according to type and are designed only as tools to assist the Composite Analysis team in qualifying the data. Ranking according to degree of certainty was not attempted because information with which to make these decisions is not complete.

Application of Data Qualification Process

Sources of information are listed below along with a definition of how they were applied:

(1) Peer-reviewed Technical Reports - SRS internally or externally published reports which contain analytical data specific to a given facility for which residual radionuclide information had been collected or documented. In this case, both quantities and types of radionuclides were known.

(2) Shipping and Disposal Records, Facility Inventories - This information had to be specific to individual types of radionuclides handled and/or disposed of at each facility as well as quantities. In this case, quantities and types of isotopes were known.

(3) Process Modeling - Information specific to the facility for which residual radionuclide information was provided through modeling based on estimated throughputs of specific radionuclides. In this case, types of radionuclides were known, but quantities were calculated based on historical throughput.

(4) Plant Operating Records - Information specific to a given facility for which residual radionuclide information had been provided based on facility operating records only, with no engineering calculations. In this case, types of radionuclides were known, but quantities were estimated based on historical throughput.

(5) Process Knowledge - Information specific to a given facility for which residual radionuclide information had been provided by plant personnel who had specific knowledge of the process by which radionuclides were processed, stored, and/or

disposed of in the past at the facility. In this case, both types and quantities of radionuclides were estimated.

(6) Waste Stream Forecast - Information specific to a given facility for which residual radionuclide information was provided by plant personnel who have specific knowledge of the process by which radionuclides will be processed, stored, and/or disposed of in the future at the facility. In this case, both types and quantities of radionuclides were also estimated.

(7) Interviews with Plant Personnel - Information specific to a given facility for which residual radionuclide information was provided by plant personnel who may not have specific knowledge of the process by which radionuclides were processed, stored, and/or disposed of at a facility but may have a general knowledge of the processes that are used at similar facilities. These plant personnel may also have knowledge of part of a facility operation but may not be familiar with all working aspects of the facility.

Summary of Data Qualification Process

During the residual radionuclide inventory collection process, 50 source facilities were identified. Table 3.3-1 provides a summary of the data qualification value assigned to each individual facility.

Table 3.3-2 is a summary table containing each of the seven data qualification numbers assigned to the various source facilities, the total number of facilities with occurrences of each qualifier, the relative percentages of each set of occurrences based on the total number of facilities, and the relative percentage of each type of occurrence based on total curies.

Table 3.3-1. List of Data Qualification Value for Each Facility Included in the Residual Radionuclide Inventory for the Composite Analysis

Facility Location	Facility Name	Data Qualifier
F-Area Separations	Canyon	5
	New Sand Filter	4
	Old Sand Filter	4
F-Area Tanks	Tanks 1-8	3
	Tanks 17-20	3
	Tanks 25-28, and 44-47	3
	Tanks 33-34	3
F Area	772-F Lab	5
	772-1F Lab	5
H-Area Separations	Canyon	5
	New Sand Filter	4
	Old Sand Filter	4
H-Area Tanks	Tanks 9-12	3
	Tanks 13-16	3
	Tanks 21-24, 29-32, and 35-37	3
	Tanks 38-43	3
	Tanks 48-51	3
H Area	ETF Receipt Tank	5
	Tritium Processing	7
E Area	Old Burial Ground	2
	Lysimeters	1
	Saltstone Lysimeters	1
	MWMF 643-7E and 643-28E (1972-1984)	2
	MWMF 643-7E and 643-28E (1985-1996)	2

Table 3.3-1. List of Data Qualification Value for Each Facility Included in the Residual Radionuclide Inventory for the Composite Analysis (Cont'd)

Facility Location	Facility Name	Data Qualifier
E Area (cont'd)	Old Solvent Storage Tanks S1-S22	5
	Old Solvent Storage Tanks S23-S30	5
	Naval Reactors KAPL CB/TS	7
	Naval Reactors KAPL Head	7
	Naval Fuel Waste	2
	E-Area Trenches	6
	Vaults LAW	6
	Vaults ILV	6
S Area	Defense Waste Processing Facility	5
	Low Point Pump Pit	5
Z Area	Saltstone Vaults	1
Various Spills	Spill at Tank 13	5
	Spill at Tank 9	5
	Spill at Tank 16	5
	Spill at Tank 37	7
	Spill at B281-3F	5
	Spill at 200-F	5
	Spill at Tank 3	5
	Spill at Tank 8	5
	Spill at B281-3H	5
Miscellaneous	Soil and Debris Consolidation Facility	1

Table 3.3-1. List of Data Qualification Value for Each Facility Included in the Residual Radionuclide Inventory for the Composite Analysis (Cont'd)

Facility Location	Facility Name	Data Qualifier
RCRA/CERCLA Facilities		
F Area	Seepage Basin GW Operable Unit	1
	Inactive Process Sewer Lines	1
H Area	Seepage Basin GW Operable Unit	1
	New Solvent Storage Tanks by CIF H33-H36	5
	Inactive Process Sewer Lines	1

Table 3.3-2. Summary List of Data Qualification Process for the Facilities Included in the Residual Radionuclide Inventory for the Composite Analysis

Data Qualifier	Total Number of Facilities by Occurrence	Percentage by Occurrence	Percentage by Total Curies
1	8	16	1.0
2	4	8	59.9
3	9	18	3.0
4	4	8	1.2
5	18	36	1.4
6	3	6	16.7
7	4	8	16.8

The seven data qualification categories can further be combined to form three general categories of facilities. These general categories are summarized in Table 3.3-3.

As defined in Table 3.3-3, both types and concentrations of radionuclides were considered known for approximately 25 percent of the facilities to be included in the Composite Analysis. Another 25 percent of the facilities had known constituents but estimated quantities. Finally, slightly over 50 percent of the facilities had both estimated types and amounts of residual radionuclides.

Also, Table 3.3-3 shows, that for the total curies included in the residual radionuclide inventory, nearly 61 percent of the total curies fall in facilities where both types and concentrations of radionuclides are considered known. Less than 5 percent of the total curies fall in the category of known constituents but estimated values. Finally, for almost 35 percent of the total curies, both types and amounts of residual radionuclides were estimated.

Table 3.3-3. Summary of the Three General Categories for the Data Qualification Process for Facilities Included in the Residual Radionuclide Inventory for the Composite Analysis

Types of Radionuclides Present	Concentrations of Radionuclides	Data Qualification Groups	Percentages by Occurrence	Percentages by Total Curies
Known	Known	1,2	24.5	60.9
Known	Estimated	3,4	22.5	4.2
Estimated	Estimated	5,6,7	53.1	34.9

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4.0 SOURCE TERM DEVELOPMENT

SRS activities in support of the national defense have produced liquid high-level radioactive waste, low-level radioactive waste, mixed waste and transuranic waste. This section describes those facilities within the General Separations Area that are expected to contain residual radioactivity when DOE operations cease at SRS.

Wastes at SRS were and continue to be generated from facility operations and environmental restoration, with facility operations generating most of the waste. During most of the period of SRS operation, the primary source of high-level waste was reprocessing of spent nuclear fuel and recovery of plutonium from reactor target tubes. A limited amount of reprocessing is scheduled to continue, with the goal of stabilizing the recovered products. In addition to this major source of waste, waste continues to be generated from purification of tritium, nuclear and non-nuclear research, material testing, laboratory analysis, high-level waste processing, nuclear fuel storage, manufacturing, repair and maintenance, and general office work. Facility operations also include operating all waste management facilities for treatment, storage, and disposal of SRS-generated wastes.

DOE treats, stores and disposes of wastes generated from all onsite operations in waste management facilities, most of which are located in the GSA within E, F, H, S and Z Areas. Major facilities include the high-level waste tank farms, the S-Area high-level waste vitrification plant, the S-Area Glass Waste Storage Buildings, the Low-Level Radioactive Waste Disposal Facility and the Saltstone Disposal Facility.

When DOE operations cease, a number of operations and processing facilities within the GSA will contain residual radioactivity. Primary among these are the F- and H-Area canyon buildings and the S-Area vitrification plant.

4.1. Potential Sources of Radioactive Material

The five main areas within the GSA are E Area, F Area, H Area, S Area, and Z Area. Activities within the GSA are primarily separations (canyon buildings in F and H Areas) and waste management (tank farms in H and F plus facilities in E, S, and Z Areas). The following sections provide brief discussions of the facilities that are included in the residual radionuclide inventory estimate.

4.1.1 E Area

Solid radioactive wastes generated at the SRS and other DOE facilities have been disposed at E Area. These wastes include contaminated equipment, laboratory wastes (e.g., gloves, beakers), and scrap and tools used in the reactor areas. The following facilities within E Area were identified as potential sources of residual radionuclide contamination for the Composite Analysis.

Lysimeters

From 1978 through 1980, 40 lysimeter units were installed in E Area to determine the leachability of SRS waste forms. These lysimeters contribute residual radionuclides to the GSA. Information concerning the residual radionuclide inventory at each lysimeter test location is provided in Hooker and Root (1981).

Mixed Waste Management Facility (643-7E and 643-28E)

The Mixed Waste Management Facility (MWMF) is a partially closed landfill that received radioactive and mixed wastes. The landfill covers 119 acres and consists of unlined burial trenches that are about 20 feet deep, 20 feet wide and of varying length.

This area also included Greater Confinement Disposal units and Naval reactor components. Radioactive waste disposal activities began in 1972 and continued through 1995. The COBRA database was used to obtain the radionuclide inventory in the MWMF (Cook 1996a).

Naval Fuel Waste

The Naval Fuel Waste area is used for storage of radioactive waste from the production of fuel for naval propulsion. The waste is currently stored in drums and boxes on storage pads in E Area. The residual radionuclide inventory estimate for the Naval Fuel Waste area was obtained from Michele Bullington of WSRC in an e-mail memorandum from Nathaniel Roddy to Jim Cook dated September 11, 1996 (Cook 1996b). There are 205 drums containing a combined total of 24.3 kg of Uranium and 99 boxes which contain a combined total of 17.6 kg of Uranium. For the purposes of the Composite Analysis, it was assumed that this waste would be placed in the E-Area Low activity Waste Vaults.

Naval Reactors

The Naval Reactors area is used for disposal of reactor components from U.S. Navy ships. The radionuclide inventory is divided into two units designated as KAPL CB/TS and KAPL Head. The U.S. Navy has projected that 32 units of KAPL CB/TS and 33 units of KAPL Head will be disposed of in the future. The Curies from each unit were further divided into the categories "Activation" and "Crud".

The residual radionuclide inventory estimate for the Naval Reactors area was obtained from Appendix L of the EAV PA, "Naval Reactor Waste Disposal." (WSRC 1994).

Old Burial Ground (643-E)

The Old Burial Ground (OBG) is a disposal facility for radioactive waste that operated from 1952 until 1972. The OBG consists of unlined trenches containing low-level alpha wastes, beta-gamma wastes, and intermediate-level beta-gamma wastes. As these trenches were filled, they were covered with soil.

The radionuclide inventory for the OBG was obtained using the COBRA database (Cook 1996a).

Old Solvent Tanks (S1-S22)

The Old Solvent Tanks, located within the 643-E Old Burial Ground, consist of 22 underground storage tanks that were used to store degraded solvent and process oil from separations processes. The tanks were first used in 1955. The solvent waste primarily consisted of degraded solvent (n-paraffin) contaminated with radionuclides. The waste was pumped from the tanks by 1981; however, the pumping operation was unable to remove all of the waste from the tanks. Residual radionuclide contamination is present in the waste heel left in the tanks.

For these tanks a total of 550 Ci of alpha emitters and 11 Ci of beta-gamma emitters are estimated to be present, based on an assumed inventory of 25 Ci of alpha emitters and 0.5 Ci of beta-gamma emitters in each tank. The alpha activity is assumed to be 40 percent ^{244}Cm, 50 percent ^{238}Pu, and 10 percent ^{239}Pu. It is also assumed that there are 0.5 Ci of beta-gamma emitters in each tank for a total of 11 Ci. The beta-gamma activity is assumed to be ^{137}Cs (Cole 1996a).

Saltstone Lysimeters

In 1983, a lysimeter test was setup in E Area to determine the leachability of Defense Waste Processing Facility (DWPF) saltstone. The saltstone lysimeters will contribute residual radionuclides to the GSA. Information concerning the residual radionuclide inventory at the saltstone lysimeter test location was provided in the report entitled "Construction and Loading of the Tank 24 Saltstone Lysimeters" (Wolf 1984).

E-Area Trenches

The E-Area Trenches are used for disposal of potentially contaminated soil from regulated areas at the SRS. Five trenches exist within the E-Area Vault facility. The top of each trench is 6 m wide and the bottom of each trench is 4.8 m wide. Each trench is 6 m deep and 200 m long. The waste in the trenches is covered with 1.2 m of clean soil. The capacity for the five trenches is approximately 26,000 m^3. The five trenches are currently projected to be filled in 20 years. The projected inventory for the E-Area Trenches at closure was estimated by Mr. Don Sink of WSRC (Sink 1996).

Solvent Tanks (S23-S30 and S32)

These Solvent Tanks (S23-S30 and S32), located within the 643-7E portion of the MWMF, were also used to store degraded solvent and process oil from the separations processes. The waste also consisted of primarily degraded solvent (n-paraffin) contaminated with radionuclides.

The closure activities for nine Solvent Tanks (S23-S30 and S32) consisted of pumping the waste from the tanks, thoroughly rinsing the tanks with water, and filling the rinsed tanks with grout. For the purposes of this radionuclide inventory estimate a total of 225 Ci of alpha emitters and 4.5 Ci of beta-gamma emitters are estimated to be in these nine tanks, based on an assumed residual activity of 25 Ci of alpha emitters and 0.5 Ci of beta-gamma emitters in each tank. The alpha activity is assumed to be 40 percent ^{244}Cm, 50 percent ^{238}Pu, and 10 percent ^{239}Pu. The beta-gamma activity is assumed to be ^{137}Cs (Shappell 1996).

Vaults

The E-Area Vaults consist of the Low-Activity Waste (LAW) Vaults and the Intermediate-Level Vaults (ILV). The ILV is further divided into the Tritium and Non-Tritium vaults.

The LAW Vaults provide engineered disposal capacity for approximately 34,000 m^3 46,000 yd^3) of low-level waste. Currently, only compacted waste is being placed into the existing LAW Vault for final disposal. An additional LAW vault is projected to be constructed and both vaults will be filled in 20 years. The projected inventory for the LAW Vaults at closure was provided by Mr. Don Purcell of WSRC (Purcell 1996).

The Intermediate-Level Non-Tritium Vault is a concrete vault with a disposal capacity of approximately 5,664 m^3 (7,650 yd^3) of intermediate-level waste. Waste containers are periodically grouted in place to further reduce radiation levels. Cells have removable concrete covers to provide radiation shielding and a rain cover to prevent rainwater from contacting the waste. The Intermediate-Level Tritium Vault is connected to the Intermediate-Level Non-Tritium vault and consists of two cells. The Tritium Vault area is approximately 1,800 m^3 (2,400 yd^3). One of the cells is fitted with silos that accept crucible waste forms for disposal, miscellaneous boxed waste is placed in the other cell.

The Intermediate-Level Non-Tritium and Intermediate-Level Tritium Vaults together are referred to as the ILV. These vaults are only used for disposal and are not used to store waste for future treatment. Currently, both vaults are projected to be filled in 20 years.

The projected inventory for the ILV was estimated by Mr. Don Sink of WSRC (Sink 1996).

4.1.2 F and H Areas

Reactor-generated products are processed in F and H Areas where uranium and plutonium are extracted from irradiated targets (Poon, 1996). Tritium is also produced in H Area. Liquid radioactive waste from production activities is stored in high-level aqueous waste tanks at the F- and H-Area Tank Farms. New Solvent Storage Tanks (H33-H36) are located in H Area near the Consolidated Incineration Facility (CIF).

235-F

Building 235-F is a metallurgical facility used for the fabrication of radioactive material. Information regarding the residual radionuclide inventory at 235-F was provided by Mr. Ray Lux (Lux 1997).

772-F and 772-1F Laboratories

The 772-F and 772-1F Laboratories are used to support projects for the Savannah River Technology Center (SRTC) and production activities at F and H Areas. For the purposes of this study, the residual radionuclides in these buildings is assumed to be 0.1 percent of the maximum radiological inventory limits for each laboratory as specified in the report entitled "Basis for Interim Operation" (WSRC 1996a).

Canyon Buildings

The F- and H-Area Canyon Buildings separate uranium, plutonium, and fission products from reactor-generated products. The separated uranium and plutonium are transferred to other facilities within F and H Areas and are processed into solid form. Fission products are stored in high-level waste tanks at the F and H Areas.

Current plans are to Decontaminate and Decommission (D&D) the canyon buildings by removing and disposing of all radioactive and hazardous materials and dismantling and disposing of the process equipment. The canyon materials and equipment will be disposed outside the facility boundaries, most likely within E Area.

For the purposes of this residual radionuclide inventory estimate, the amount of residual radionuclides remaining at each canyon facility after D&D is assumed to be 0.1 percent of the actinide inventory limits provided in the Inter-Office Memorandum from Mike Low (Safety Documentation Group) to Jimmy Starling (Safety Services) entitled "Revised Inventory Limits for Selected NMSP Facilities", (WSRC, 1996b). Fission products were then added based on the amount of ^{239}Pu present (Apperson 1983).

F- and H-Area Sand Filters

The F- and H-Area Sand Filters are part of the off-gas system for the F- and H-Area separations facilities. The sand filters are contaminated with radionuclides; therefore, they may contribute to the Composite Analysis. For the purposes of this study, the two old sand filters were assumed to have operated from 1960 through 1990 and the two new sand filters operated from 1975 through 1990. Measurements show that during canyon operations each of the filters accumulate a total of 2000 Ci/year of beta-gamma activity and 0.5 Ci/year of alpha activity. The beta-gamma activity is assumed to be composed of 32.8 percent ^{106}Ru, 12.6 percent ^{137}Cs, and 54.6 percent ^{144}Ce (Sykes and Harper 1968).

The alpha activity is assumed to be composed of ^{239}Pu in the F-Area Sand Filter and ^{238}Pu in the H-Area Sand Filter.

Tritium Production

Tritium is processed at facilities within H Area. The current operations take place within buildings 232-H, 233-H, and 234-H. Tritium is extracted and separated from irradiated targets and is processed and packaged for shipment to other DOE facilities. The only significant by-product from tritium production operations is ^{65}Zn. Since ^{65}Zn has a half-life of less than one year, it will not be a significant contributor to the residual radionuclide inventory estimate for the tritium production facilities.

Current plans are to D&D these buildings by removing and disposing of all radioactive and hazardous materials and dismantling and disposing of the process equipment. The tritium production materials and process equipment will be disposed of outside the facility boundaries, most likely within E Area. For the purposes of this residual radionuclide inventory estimate, the amount of residual radionuclides remaining after D&D is assumed to be 10,000 Ci of tritium for each of the three tritium production buildings (Hsu 1996).

Tritium production also took place in F Area at Building 232-F; however, production was stopped in November 1958 and the building has undergone D&D. Based on current plans, building debris will be sent to the E-Area Trenches for disposal.

F- and H-Area High-Level Tank Farms

High-level aqueous radioactive waste and evaporated saltcake is stored in large underground storage tanks at the F- and H-Area Tank Farms. There are 22 tanks in F Area and 29 tanks in H Area. The wastes will be removed from the tanks and processed in the DWPF. For this inventory, the tanks were grouped based on their locations as follows:

F-Area Tanks

- Tank Nos. 1 through 8
- Tank Nos. 17 through 20
- Tank Nos. 25 through 28 and 44 through 47
- Tank Nos. 33 and 34

H-Area Tanks

- Tank Nos. 9 through 12
- Tank Nos. 13 through 16
- Tank Nos. 21 through 24, 29 through 32, and 35 through 37
- Tank Nos. 38 through 43
- Tank Nos. 48 through 51

Current plans are to close the tanks in place by removing the vast majority of the high-level waste stored in the tanks, thoroughly rinsing the tanks, removing ancillary equipment from the top of the tanks, placing any contaminated equipment in the tank and then filling the tanks with backfill. Equipment installed inside the tanks will be left in place (USDOE 1996b). For the purposes of this residual radionuclide inventory, the majority of the tanks are assumed to have 378 L (100 gal) of sludge remaining after cleaning; a few of the tanks are assumed to have as much as 7570 L (2000 gal) of sludge remaining prior to filling with grout (d'Entremont 1997; Hester 1996a; Hester 1996b). Ancillary equipment such as piping and pumps will add 20 percent to the residual radionuclide total for the tanks. The density of the sludge is expected to be about 0.234 kg/L (1.95 lb/gal).

Effluent Treatment Facility

The ETF is located on the south side of H Area. The ETF collects and treats routine process wastewater, contaminated canyon facility cooling water, and tank farm storm water runoff from the F and H Areas. Except for tritium (present as tritiated water), the ETF removes radioactive and nonradioactive contaminants from process effluents; the purified water is discharged to Upper Three Runs.

With the possible exceptions of the ETF Receiving Tank and the ETF Basins, the ETF is not expected to be contaminated with a significant inventory of radionuclides. For the purposes of this residual radionuclide inventory, 1000 L (264 gal) of contaminated ETF influent is assumed to remain in the ETF Receiving Tank after D&D activities for the tank are completed.

The ETF Basins are lined basins that have received water contaminated with radionuclides. Tears have been found in the basin liner above the water line; therefore, the ETF Basins are a potential source of residual radionuclides for the Composite Analysis. The water stored in the basins had very low radioactivity and the sediments in the basins were found to have only 4.5×10^{-10} Ci/gm of ^{137}Cs (Wiggins 1997). Using the dimensions of the ETF Basins and a conservative estimate of 7.6 cm (3 in) of sediment left in the basins, the residual radionuclide contribution of ETF Basins is less than 1 Ci; therefore, the contribution is insignificant and the ETF Basins have not been included in this inventory estimate.

Naval Fuel Materials Facility (247-F)

The Naval Fuel Materials Facility manufactured nuclear fuel for the U.S. Navy. The facility was cleaned prior to shut down in 1989; however, approximately 17 kg of uranium remained in the facility (Lux 1996). The uranium is made up of ^{234}U, ^{235}U and ^{238}U.

RCRA/CERCLA Sites within F and H Areas

Existing RCRA/CERCLA sites within the F and H Areas are the Closed Basins (F-Area Seepage Basin Groundwater Operable Unit and H-Area Seepage Basin Groundwater Operable Unit), the Closed Process Sewer Lines (F-Area Inactive Process Sewer Lines and H-Area Inactive Process Sewer Lines), and the New Solvent Storage Tanks (H33-H36).

- F- and H-Area Seepage Basin Groundwater Operable Units

The Groundwater Operable Units for the F- and H-Area Seepage Basins are RCRA/CERCLA sites that contain residual radionuclides. Information regarding the residual radionuclide inventory in the F- and H-Area Seepage Basins was obtained from Mr. Cole (Cole 1998).

- F- and H-Area Inactive Process Sewer Lines

The process sewer lines in F and H Areas were used to transport contaminated wastewater (hazardous and LLW) to the seepage basins. These vitrified clay sewer lines were used from 1955 until 1982 when new PVC process sewer lines were placed in service. Some leakage occurred from the vitrified clay lines.

For the purposes of this residual radionuclide inventory estimate, the amount of residual radionuclides associated with the process sewer lines was calculated by Mr. Clifford Cole, Sr. (Cole 1996c). Mr. Cole conservatively assumed that the highest contamination level reported represents a homogenous concentration of radionuclides in the soil along each sewer line. Mr. Cole also assumed that each sewer line is 1524 m (5,000 ft) long, the excavation is 3 m (10 ft) wide by 3 m (10 ft) deep, and the soil density is 1920 kg/m^3 (120 lb/ft^3).

Effluent Treatment Facility

The ETF is located on the south side of H Area. The ETF collects and treats routine process wastewater, contaminated canyon facility cooling water, and tank farm storm water runoff from the F and H Areas. Except for tritium (present as tritiated water), the ETF removes radioactive and nonradioactive contaminants from process effluents; the purified water is discharged to Upper Three Runs.

With the possible exceptions of the ETF Receiving Tank and the ETF Basins, the ETF is not expected to be contaminated with a significant inventory of radionuclides. For the purposes of this residual radionuclide inventory, 1000 L (264 gal) of contaminated ETF influent is assumed to remain in the ETF Receiving Tank after D&D activities for the tank are completed.

The ETF Basins are lined basins that have received water contaminated with radionuclides. Tears have been found in the basin liner above the water line; therefore, the ETF Basins are a potential source of residual radionuclides for the Composite Analysis. The water stored in the basins had very low radioactivity and the sediments in the basins were found to have only 4.5×10^{-10} Ci/gm of ^{137}Cs (Wiggins 1997). Using the dimensions of the ETF Basins and a conservative estimate of 7.6 cm (3 in) of sediment left in the basins, the residual radionuclide contribution of ETF Basins is less than 1 Ci; therefore, the contribution is insignificant and the ETF Basins have not been included in this inventory estimate.

Naval Fuel Materials Facility (247-F)

The Naval Fuel Materials Facility manufactured nuclear fuel for the U.S. Navy. The facility was cleaned prior to shut down in 1989; however, approximately 17 kg of uranium remained in the facility (Lux 1996). The uranium is made up of ^{234}U, ^{235}U, and ^{238}U.

RCRA/CERCLA Sites within F and H Areas

Existing RCRA/CERCLA sites within the F and H Areas are the Closed Basins (F-Area Seepage Basin Groundwater Operable Unit and H-Area Seepage Basin Groundwater Operable Unit), the Closed Process Sewer Lines (F-Area Inactive Process Sewer Lines and H-Area Inactive Process Sewer Lines), and the New Solvent Storage Tanks (H33-H36).

- F- and H-Area Seepage Basin Groundwater Operable Units

The Groundwater Operable Units for the F- and H-Area Seepage Basins are RCRA/CERCLA sites that contain residual radionuclides. Information regarding the residual radionuclide inventory in the F- and H-Area Seepage Basins was obtained from Mr. Cole (Cole 1996b).

- F- and H-Area Inactive Process Sewer Lines

The process sewer lines in F and H Areas were used to transport contaminated wastewater (hazardous and LLW) to the seepage basins. These vitrified clay sewer lines were used from 1955 until 1982 when new PVC process sewer lines were placed in service. Some leakage occurred from the vitrified clay lines.

For the purposes of this residual radionuclide inventory estimate, the amount of residual radionuclides associated with the process sewer lines was calculated by Mr. Clifford Cole, Sr. (Cole 1996c). Mr. Cole conservatively assumed that the highest contamination level reported represents a homogenous concentration of radionuclides in the soil along each sewer line. Mr. Cole also assumed that each sewer line is 1524 m (5,000 ft) long, the excavation is 3 m (10 ft) wide by 3 m (10 ft) deep, and the soil density is 1920 kg/m^3 (120 lb/ft^3).

- New Solvent Storage Tanks (H33-H36)

The New Solvent Storage Tanks (H33-H36) were built to store radioactive waste solvent from the separations activities. For the purposes of this residual radionuclide inventory estimate, 25 Ci of alpha emitters and 10 Ci of beta/gamma emitters will remain in each tank after they have been emptied and decontaminated For these four tanks, a total inventory of 100 Ci of alpha emitters and 40 Ci of beta/gamma emitters is assumed. The alpha activity is assumed to be composed of 40 percent ^{244}Cm, 50 percent ^{238}Pu, and 10 percent ^{239}Pu. The beta/gamma activity is assumed to be due to only ^{137}Cs.

4.1.3 S Area

The DWPF is located in S Area. The DWPF is used to vitrify high-level radioactive waste. The DWPF accepts liquid high-level radioactive waste stored in the F- and H-Area Tank Farms. The waste is pumped through a pipeline from H Area to the DWPF and passes through the Low Point Pump Pit located in S Area. Operations at the DWPF involve immobilizing the high-level waste by mixing the waste with glass frit and melting the blend of waste and frit to produce molten glass. The glass is poured into stainless steel canisters and allowed to cool to an inert solid material which is suitable for storage onsite in the Glass Waste Storage Building until it can be transferred to an offsite geologic repository for disposal.

A by-product of the DWPF operations is waste benzene, contaminated with radionuclides. The waste benzene is transferred to the Organic Waste Storage Tank (OWST) at S Area for storage until it can be transferred to the CIF for incineration. The amount of radioactive material in the OWST is very low (less that 1 Ci) (USDOE 1994); therefore, the OWST is not included in this residual radionuclide inventory estimate.

Current plans are to D&D the DWPF building and Low Point Pump Pit by removing and disposing of all radioactive and hazardous materials and dismantling and disposing of the process equipment. For the purposes of this residual radionuclide estimate, 3,785 L (1000 gal) of typical DWPF sludge slurry is assumed to remain in the DWPF canyon building and 189 L (50 gal) of typical DWPF sludge slurry is assumed to remain in the Low Point Pump Pit after D&D activities are completed.

4.1.4 Z Area

The Z-Area Saltstone Facility is designed to process and dispose of decontaminated salt solutions from the F- and H-Area Tank Farm and the ETF. The decontaminated salt solution is mixed with a blend of slag, fly ash, and cement to generate a grout. The grout is transferred to concrete vaults for disposal where it solidifies to a stable, monolithic solid called Saltstone.

The Composite Analysis radionuclide inventory for the Saltstone vaults was taken directly from the facility Performance Assessment (WSRC 1992b).

4.1.5 Spills within the GSA

Accidental spills and releases of radioactive waste have occurred at the SRS and have been documented, in various degrees, since 1954 (Stephens and Ross 1984). For the purposes of this residual radionuclide inventory estimate, all spills with an activity of less than one Curie are considered to be insignificant and have not been included. This resulted in two spills in the High Level Waste Tank Farms being included in the analysis.

4.1.6 Other RCRA/CERCLA Sites

Soil/Debris Consolidated Facility

The Soil/Debris Consolidated Facility (SDCF) is a waste disposal facility that will be built in the future (Cole 1996d). Contaminated soil and debris from four SRS facilities will be disposed in the SDCF. The residual radionuclide inventory at the SDCF was obtained by adding the projected radionuclide inventory from the four facilities contributing waste to the SDCF (Cole 1996f; Cole 1996g; Cole 1996h;Cole 1997). The following facilities will contribute waste to the SDCF:

- Ford Building Seepage Basin

The Ford Building Seepage Basin (FBSB) is an unlined basin approximately 18 m (60 ft) by 6 m (20 ft) at the bottom and 24 m (80 ft) by 12 m (40 ft) at the ground level with a depth of 3 m (10 ft). An underground retention tank with a capacity of 22,700 L (6,000 gal) is located adjacent to the Ford Building and is connected to the seepage basin by an underground sewer pipeline. The FBSB was used for the disposal of wastewater from the Ford Building from 1964 to 1984. The basin received a total of 1.44 million L (380,400 gal) of wastewater during this 20 year period. The FBSB and connecting underground retention tank are currently inactive and have not been backfilled. The radionuclide inventory was determined from soil core analysis (Stewart and Hamilton 1997).

- Ford Building Waste Site

The origin and history of waste disposal at the Ford Building Waste Site (FBWS) is unknown, although radioactive regulated equipment is suspected to have been worked on at this site. Current knowledge indicates that an unknown volume of oil may have been discharged at the site in the 1970s (Cole 1996e). The radionuclide inventory was determined from waste characterization forms for excavated soil and rubble (Stewart and Hamilton 1997).

- Savannah River Laboratory Seepage Basins

The Savannah River Laboratory Seepage Basins (SRLSBs) consist of four unlined basins used to dispose of low-level radioactive liquid waste generated in buildings 735A and 773A. The SRLSBs are inactive but have not been backfilled.

- TNX Burial Ground

The TNX Burial Ground (TNXBG) was used as a solid waste management unit. An estimated 27 g of depleted uranyl nitrate remains buried in the TNXBG (DOE 1987).

During the course of work on the Composite Analysis, management determined that a separate disposal facility for Environmental Restoration waste was not warranted. The inventories for the four facilities described above were added to that of the E-Area trenches.

Contaminated Stream Sediments

The sediments in the streams that bound the GSA, Four Mile Branch and Upper Three Runs, have potentially been contaminated with radionuclides released to the environment during operations at the SRS. As with other potential sources of radioactive material, only the sediments within the GSA are considered because it is those sources that could influence decisions regarding operations of the LLW disposal facilities.

4.2 Excluded Sources

The following types of facilities within the GSA were excluded from this residual radionuclide inventory estimate:

- Facilities that have never been associated with the processing, management, or disposal of radioactive materials or waste such as the Burma Road Rubble Pit, the H-Area Acid/Caustic Basin, and the 284-10F Maintenance Shop. Such facilities are assumed to be free of radionuclide contamination.

- Administration buildings such as offices, control rooms, laundry rooms, or clothing change rooms. Although these facilities may support other facilities that manage or dispose of radioactive materials or waste, sufficient controls are assumed to be in place to ensure that these facilities are free of radionuclide contamination.

- Temporary storage facilities such as material staging areas, waste storage buildings or pads, or equipment storage areas. These facilities are assumed to be free of radionuclide contamination because either the probability of radioactive contamination is low or they can be completely decontaminated of all residual radionuclides..

- Mechanical equipment and systems such as diesel generators, exhaust systems, or cooling water systems. These facilities are assumed to be free of radionuclide contamination because either the probability of radioactive contamination is low or they can be completely decontaminated of all residual radionuclides.

- Facilities where radioactive material or waste was processed, managed, stored or disposed of but there is very little chance of residual contamination such as the Glass Waste Storage Building, the Beta Gamma Incinerator, the Consolidated Incineration Facility, the Waste Truck Unloading Station(211-3F), or the Waste Certification

Building (724-8E). These facilities are assumed to be free of radionuclide contamination because materials processed have extremely low concentrations of radioactive contaminants, the probability of radioactive contamination is very low because radioactive materials are contained within externally clean containers, or they can be completely decontaminated of all residual radionuclides

- Facilities or spill areas where the maximum amount of total radionuclides that could ever be present is less than 1 Curie, even though radioactive materials or waste were processed, managed or spilled. Examples of such facilities include the Effluent Treatment Facility (ETF) Basins, the spill at 200-F and UTR stream sediments within the GSA (Carlton et al. 1992). Residual radionuclides that total less than 1 Curie for an entire facility or spill area are negligible, especially when compared to the total residual inventories in all of the facilities within the GSA.

The following assumptions were made for reporting the radionuclides present at the GSA facilities.

- Radionuclides reported as "Gross Alpha" and "Other Alpha" are assumed to be ^{239}Pu.

- Radionuclides reported as "Non-Volatile Beta" are assumed to be ^{90}Sr.

- Radionuclides reported as "Other Beta-Gamma" are assumed to be ^{137}Cs.

- Radionuclides reported as "Radium" are assumed to be ^{226}Ra.
- The radionuclide reported as iAm-241 (which is meant to designate ^{241}Am as a daughter radionuclide) is assumed to be Am-241.

- Radionuclides reported with daughter notation (i.e., "+d") are recorded on the summary sheet as without daughters. For example, ^{90}Sr+d is recorded as ^{90}Sr. This notation is a remnant of the notation used in performance assessments to identify decay daughters that must be considered in an intruder analysis.

4.3 Transport Pathway Identification

Dominant transport pathways, ultimately leading to human exposure to radionuclides potentially released from GSA sources, must be identified before source terms are estimated. Source term estimates are specific for each transport pathway. For example, if groundwater transport is deemed important, then an estimate of the leach rate for a subsurface source is required. Likewise, if resuspension of surface soil is considered an important pathway to exposure, then root uptake by vegetation and the activity of burrowing animals must be estimated to develop the source term at the ground surface. In this section, both the potentially important pathways to human exposure and those pathways that can be eliminated from further consideration by virtue of their very low contribution to a measurable dose are identified.

A generalized diagram of pathways to human receptors from a subsurface source of radionuclides is given in Fig. 4.3-1. The pathways identified in this figure are for undisturbed sources, from the standpoint of human intrusion. Boxes in Fig 4.3-1 represent ecosystem compartments that could be contaminated with radionuclides initially introduced into the environment from a subsurface source. Arrows represent pathways of radionuclide movement from the source, between compartments, and eventually to human receptors.

For a subsurface source, radionuclides may be leached by infiltrating water into underlying aquifers or isolated perched water zones, they may diffuse in the air-filled voids in the soil to the ground surface, or they may be moved to the surface soil by burrowing animals or

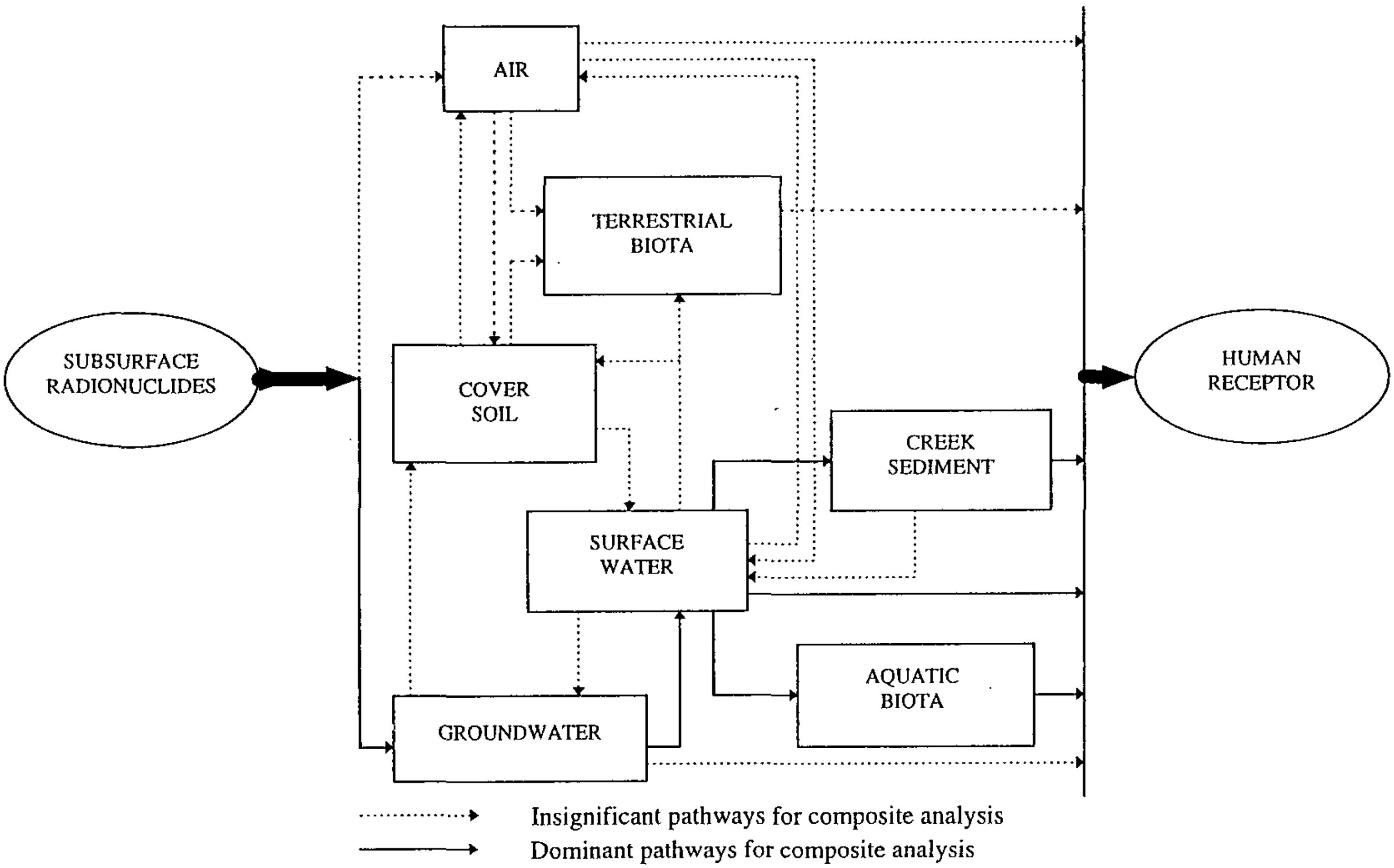

Figure 4.3-1. Pathways to human receptors from subsurface radionuclides.

deep tree roots. Radionuclides that are leached to groundwater may be ingested by humans directly, transported to the ground surface as a result of irrigation with groundwater, or they may eventually reach surface water at locations where there are seeps or streams.

The arrow leading directly from the "Groundwater" box in Fig. 4.3-1 to the human receptor is broken to indicate that this pathway is not considered a significant route of human exposure in this analysis. Elimination of this route follows from plans for future use (Appendix A) of the SRS, because unrestricted use of the region of the SRS in which groundwater could be contaminated by the GSA sources will not occur. Upper Three Runs Creek and Fourmile Branch effectively intercept groundwater aquifers beneath the GSA that could be potentially contaminated by the GSA sources. The spread of contamination in groundwater beneath the GSA to groundwater beyond these two creeks is not a concern.

As depicted in Fig. 4.3-1, radionuclides in groundwater may exchange with surface water and cover soil. The streams on the SRS are gaining streams; therefore, groundwater is not recharged by the streams and radionuclides discharged to the streams will not contaminate groundwater in locations downstream from the GSA. This is indicated in Figure 4.3-1 by the broken line leaving the "Surface Water" compartment and entering the "Groundwater" compartment. However, groundwater from beneath the GSA does discharge to local streams on the SRS; thus, radionuclide movement from groundwater to surface water is potentially significant, and is addressed in the composite analysis.

Radionuclides may move through groundwater either as dissolved constituents or in a suspended colloidal form. Colloidal migration is a very dynamic process. As suspended colloids encounter slight changes in water chemistry or flow rate along a flow path, they may either deposit on the immobile soil surfaces, or become mobilized. Therefore, colloidal transport in natural aquifer media can be viewed as a process with attributes similar to those governing sorption and desorption of elements and compounds. Colloidal forms are not explicitly addressed in this analysis for two reasons, discussed below.

First, colloidal forms are not directly addressed in this analysis because reliable means of predicting site-specific colloidal influences on solute migration are not available. The types of colloids present are not readily measured, and thus the sorptive potential and stability of the colloids cannot be predicted. Second, colloids migrate according to complex physical and chemical immobilization and remobilization mechanisms. These mechanisms are not easily determined in non-idealized media such as natural aquifer materials. Because of these and other uncertainties, many conservative assumptions are used in the composite analysis to assure that these indeterminate effects attributable to colloids will not have a significant influence on the results.

For liquid transport computations used in this analysis, a sorption coefficient, normally referred to as a K_d, is used to partition a radionuclide between the solid and liquid phases. Coefficients for each radionuclide are empirically determined, and are calculated from experimental tests that either measure "liquid phase" and solid phase concentrations of radionuclides, or measure the retardation that occurs as a result of reversible sorption processes when liquid constituents move through a porous medium. "Liquid phase" in both of these measurements is defined as that portion of the experimental media that passes through a filter of a specified pore size. Because of this definition, the "liquid phase" may actually contain some colloidal solid material that also passes through the filter. This colloidal material is very sorptive because the particles are small with a very high surface to volume ratio. Thus, an experimentally determined K_d may include the colloidal fraction passing through the filter, and may underestimate the true sorption potential of the porous media that is being tested. Because an experimental K_d may yield a liquid phase concentration that is greater than or equal to the true solubility of a radionuclide due to the presence of colloids, calculated doses from liquid pathways will always be conservative.

Irrigation of cover soil by groundwater is practiced only occasionally in the SRS region, due to abundant precipitation during the growing season (Murphy 1990). Because the groundwater under the SRS is intercepted by on-site surface water streams rather than flowing off-site, groundwater irrigation is not an important pathway to cover soil, and ultimately to human exposure. Accordingly, in Fig. 4.3-1, the arrow that represents the groundwater irrigation pathway from the "Groundwater" compartment to the "Cover soil" compartment is broken.

Volatile radionuclides that diffuse to the ground surface may be transported in air and eventually inhaled by humans. These radionuclides may also exchange with the cover soil and terrestrial biota compartments. Deposition on cover soil and plant surfaces leads to exposure via ingestion of crops, milk or beef.

In the Composite Analysis for the GSA, the radionuclide inventory includes significant quantities of ^{3}H and ^{14}C, which have volatile forms. In order to evaluate the potential significance of the atmosphere pathway, tritium monitoring data for the SRS were consulted.

The 1995 Environmental Monitoring Report (WSRC 1996d) provides information on current atmospheric releases of radionuclides from the SRS, and dose associated with them. In 1995, the SRS released 55,000 Ci of tritium oxide from all areas of the site, with an estimated dose of 0.06 mrem to the maximally-exposed individual at the site boundary. Most of the tritium oxide (42,000 Ci) came from the GSA. Air monitors installed around the E-Area solid waste disposal facilities and in H-Area showed average tritium oxide concentrations in air of about 250 pCi/m^3 and 650 pCi/m^3, respectively, in 1995. The 42,000 Ci released in 1995 from the GSA is greater that the estimated residual inventory for the E-Area and H-area facilities. Therefore, the atmospheric dose that would be calculated for the residual inventory in these facilities would be less than 0.06 mrem/year, even if the entire residual inventory were released in one year.

The estimated inventory of tritium in the Old Burial Ground, the Mixed Waste Management Facility and the E-Area Vaults is 6.9 x 10^6 Ci, about 125 times the total amount released from all of SRS in 1995. Using a simple ratio and assuming all tritium oxide, if this entire inventory were released in one year the calculated dose to the maximally-exposed individual would be 7.5 mrem/yr (since the 0.06 mrem/yr dose was based on the 55,000 Ci SRS release).

Though several million curies of tritium have been buried in E-Area since the mid 1950s, the air monitoring results are so low that E-Area is classified as having no air emission sources. Because of decay, infiltrating water sweeping through the vadose zone and release to the groundwater little, if any, tritium activity is released to the atmosphere. Factors which limit release of tritium to the atmosphere are likewise expected to limit ^{14}C releases. In addition, 6800 Ci (94 percent) of the ^{14}C in the GSA is on ion exchange resins, which are buried in sealed stainless-steel vessels, further limiting release of this radionuclide.

Based on the above observations, it was not considered credible that any doses due to the atmospheric pathway could come within orders of magnitude of the 100 mrem/yr dose objective or the 30 mrem/yr dose constraint for the maximally exposed individual. Therefore, the atmospheric pathway was eliminated from further consideration, as indicated in Figure 4.3-1.

Although volatile radionuclides may also partition into surface water from the air, this pathway is neglected for this analysis because the dilution provided by air minimizes the contribution of this phenomenon relative to the direct discharge of radionuclides in groundwater at the creeks.

Radionuclides that are transported to the cover soil by burrowing animals or intrusive roots may be resuspended into air, or taken up by terrestrial biota. Although the significance of burrowing animals or root uptake is difficult to quantify, neither of these pathways are expected to lead to significant human exposure for two reasons. First, the presence of dense vegetation at the site limits resuspension of particulates from the GSA. Thus, human exposures via this route are not likely. Second, according to plans for future use planning of the SRS, terrestrial biota used for human consumption will not be cultivated in the GSA. Long-term control of the GSA will also prevent deep-rooted species, such as pine trees, from growing over sources of radioactive material. This could be accomplished by planting alternative climax vegetative species such as bamboo (Salvo and Cook, 1993). Therefore, cover soil contaminated as a result of on-site burrowing animals or intrusive roots is considered a negligible source of potential human exposure in this Composite Analysis. The arrow leading from the "Subsurface Radionuclides" to the "Cover Soil" compartment in Fig. 4.3-1 is broken to indicate the negligible contribution of this pathway to human exposure.

Radionuclides in surface water may be ingested directly by human receptors, taken up by aquatic biota, exchanged with sediment, volatilized to the air, or transferred to the surface soil as a result of irrigation with surface water (Fig. 4.3-1). Ingestion of potentially contaminated surface water is considered a relatively significant pathway to human exposure in this analysis, as is contamination of aquatic biota. Because fish can bioaccumulate radionuclides, ingestion of contaminated fish could lead to exposures exceeding those associated with ingestion of contaminated water.

Radionuclides may exchange with creek sediment, according to their sorption potential. Deposition (or sorption) onto sediments is addressed in this analysis and external exposures to shoreline deposits are calculated. However, the surface water (and aquatic biota) pathway conservatively neglects the concentration-depleting effect of deposition on sediments, thereby increasing the peak concentration for each radionuclide in surface water. Because of this latter assumption, resuspension and/or desorption of radionuclides sorbed on sediment are not explicitly addressed in ingestion pathways related to surface waters.

Radionuclides that have a volatile form, such as ^{3}H and ^{14}C, may volatilize from contaminated surface water. This pathway, however, is insignificant compared to the quantity of these radionuclides that could volatilize from the soil, because the radionuclides are considerably more dilute in surface water. Therefore, the corresponding arrow in Fig. 4.3-1 is broken.

Irrigation of cover soil and terrestrial biota with contaminated surface water is also neglected in this analysis. Again, because of abundant rainfall, irrigation by surface water is only occasional. Furthermore, crops or other terrestrial biota irrigated by surface water are not likely to significantly increase human exposure over the exposure derived from direct ingestion of surface water.

In the analyses done for the E-Area PA, exposures from drinking water exceeded exposures from the meat-milk-vegetable-soil ingestion pathway for a sampling of radioactive contaminants that have relatively high uptake dose factors. Four radionuclides were selected as representative of those potentially significant to an irrigation scenario: Tc-99, Sn-126, Pu-239, and Cs-137. Technetium-99 was selected because it represents radionuclides with relatively high vegetative uptake factors, similar to H-3 and C-14. However, although uptake potential is high, leaching from the root zone is rapid, as is typically the case; i.e., vegetative uptake and Kd are correlated. Tin-126 was selected because it has a moderately high Kd, and thus is retained in the root zone, and has a significant external dose factor. Plutonium-239 was selected because it has a high Kd and a high internal dose factor (although a low vegetative uptake factor). Finally, Cs-137 was selected because it has a high Kd and also a moderate vegetative uptake factor, which is an anomaly.

For Tc-99, Pu-239, and Cs-137, the dose from all pathways associated with irrigation are approximately factors of 6, 4, and 8 lower, respectively, than doses from the drinking water pathway. For Sn-126, the dose from irrigation pathways is about one-half the dose from the drinking water pathway, due to external exposure to radiation from this isotope when deposited on garden soil. These calculations assumed that half of all vegetables consumed were irrigated with contaminated water at a rate consistent with what may be found in the SRS region, and that all milk and beef consumed were derived from dairy and beef cattle that drink contaminated water. Because these assumptions are conservative, estimated exposures from cultivated foods and soil are not expected to exceed those attributable to drinking water, but are expected to be several times lower. Therefore, the surface water irrigation pathway is not considered a dominant pathway to human exposure.

In summary, the following transport pathways are identified as important to the Composite Analysis: groundwater transport from the subsurface source of radionuclides to surface water, and surface water transport to human receptors via direct ingestion and via aquatic biota and creek sediment. In the next section, the source terms describing release of radionuclides to the groundwater compartment and the air compartment are presented.

4.4 Source Term Estimates

4.4.1 Inventory Estimates

Data for the radionuclide inventory estimates were collected from a variety of sources including reports, WSRC memoranda, and process knowledge estimates. Table 3.2-1 lists the contacts who provided information.

The initial list of potential radionuclide sources was developed by the Data Resource Team (see Table 3.2-1) and focused on specific facilities within the F, H, S, Z, and E Areas. This list was expanded to include all facilities within the GSA that were associated with radioactive material (CDM 1996). Data was provided by various technical personnel at WSRC. Additional data were gathered from a variety of sources which included reports, WSRC memoranda, process knowledge estimates, and interviews.

The original list was condensed to be a working list of facilities. Table 4.4-1 identifies those facilities within the GSA considered but not included in the residual radionuclide inventory. The reason that a particular facility was rejected is included in the table. There are four reasons that a facility may have been rejected: No Radionuclides, Clean, Radionuclides < 1 Ci, or Storage. The designation "No Radionuclides" was used for those facilities that have never been associated with radioactive material. The designation "Clean" was used for those facilities that processed radioactive material but are expected to be completely free of residual radionuclide contamination as a result of D&D efforts. The designation "Radionuclides < 1 Ci" was used for facilities and spills where the maximum amount of radionuclides that could be present is less than 1 Ci. The designation "Storage" was used for facilities that were used for temporary storage.

Table 4.4-2 presents the inventory for each facility which is expected to contain residual radioactive material.

Appendix E provides the work sheets and data for the radionuclides and facilities included with this inventory estimate.

Table 4.4-1. Facilities Considered but not Included in Inventory

Area	Facility	Building Number	Reason Not Included
E Area			
	Used Equipment Storage Area	643-7E	No Radionuclides
	Mixed Waste Storage	643-29E, -43E	Storage
	TRU Waste Storage Pad	643-7E	Storage
	Waste Certification Bldg.	724-8E	Clean
F Area			
	Waste Truck Unloading	211-3F	Clean
	U Oxide Storage	221-12F, 221-22F	Storage
	Cooling Water System	281-1F, - 6F, -25F	Clean
	U Oxide Storage	728-F, 730-F	Storage
	Diesel Generator	254-5F	No Radionuclides
	Maintenance Shop	284-10F	No Radionuclides
	F Canyon Exhaust System (Fans, Filter Houses, Stacks)	292-F, 294-F	Clean
	Burma Road Rubble Pit	231-4F	No Radionuclides
	F-Area Burning/Rubble Pit	231-F, -1F, -2F	No Radionuclides
	F-Area Coal Pile Runoff Basin	289-F	No Radionuclides
	F-Area Hazardous Waste Management Facility	904-41G, -42G, -43G	No Radionuclides
	ETF Basins	281-8F, -97F	Radionuclides < 1 Ci
H Area			
	Diesel Generators	218-H, 234-4-H, 238-H, 254-10H	No Radionuclides
	Building Exhaust System	295-H, 296-H, 297-H, 298-H	No Radionuclides
	H Cooling Water System	241-103H, 281-13H, -18H	Clean
	Consolidated Incineration Facility	261-H	Clean

Table 4.4-1. Facilities Considered but not Included in Inventory (continued)

Area	Facility	Building Number	Reason Not Included
H Area (continued)			
	Beta Gamma Incinerator	230-H	Clean
	Compactor Building	253-H	Clean
	H-Area Coal Pile Runoff Basin	289-H	No Radionuclides
	H-Area Acid/Caustic Basin	904-75G	No Radionuclides
	ETF Control Room	241-84H	No Radionuclides
	ETF Treatment Building	241-81H	Clean
	ETF Basins	241-8H, -103H	Radionuclides < 1 Ci
Tritium Facilities			
	Receiving Basin for Off Site Fuel	244-H	Clean
	Resin Regeneration	245-H	Clean
	Isotope Separation/Purification Facility, Lines I/II/III	232-H	Clean
	Tritium Inventory Storage Area	217-H	Storage
	Storage, Spare Parts, and Shipping	237-H	Clean
	By Product Purification Facility	236-H	Clean
	Burst Test Facility	236-1H	Clean
	Reservoir Reclamation Facility	238-H	Clean
	Bldg. 232-H Exhaust Stack, Lines II	295-H	Clean
	Building 234-H Exhaust Stack	296-H	Clean
	Building 232-H Exhaust Stack, Line III	297-H	Clean

Table 4.4-1. Facilities Considered but not Included in Inventory (continued)

Area	Facility	Building Number	Reason Not Included
S Area			
	Glass Waste Storage Building	250-S	Storage
	Organic Waste Storage Tank (OWST)		Radionuclides < 1 Ci
Z Area			
	Process Building	210-Z	Clean
	Saltstone Operations Building	704-Z	Clean
Spills			
	Spill at 200-F	200-F	Radionuclides < 1 Ci
Stream Sediments	UTR sediments within GSA		Radionuclides < 1 Ci

Residual Radionuclide Summary

E Area

	Lysimeters	MWMF	MWMF	Naval Fuel Waste	Naval Reactors KAPL CB/TS	Naval Reactors KAPL Head	Old Burial Ground	Old Solvent Tanks S1-S22	Saltstone Lysimeters	E-Area Trenches	Solvent Tanks S23-S30 and S32	Vaults LAW	Vaults ILV
Building Number	643-7E	643-7E and 643-28E		643-7E	643-7E	643-7E	643-E	643-E	643-7E	643-7E	643-7E	661-6E	662-6E
Site Map Page No.	10	10, I-3		10, G-12 and G-13	12,B-10	12,B-10	10, A-12	10	10	10	10	10	10
Dates of Operation	1978 - 1980	1972 - 1988	1988 - 1996	1989	1994 - 2014	1994 - 2014	1952 - 1972	1955 - 1981	1983	1995 - 2015	1981 - 1997	1995 - 2015	1995 - 2015
Total Volume	Data Unavailable	Data Unavailable	Data Unavailable	41.9 Kg	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	7500 gal	26000 m^3	Data Unavailable	34000 m^3	7464 m^3
Reference No.	1, 2	2, 3	2, 3	4	5	5	3	6	7	8, 9	10	11	9
H-3	---	2.06E+06	2.34E+05	---	4.32E+02	6.67E-04	2.12E+06	---	7.39E-01	8.75E+00	---	1.66E+06	8.80E+05
C-14	1.75E+00	1.86E+03	1.86E+03	---	4.33E+02	1.49E+00	3.09E+03	---	2.53E-04	---	---	1.70E-01	2.24E-03
Na-22	1.02E-03	---	---	---	---	---	---	---	---	---	---	---	---
Al-26	---	---	---	---	---	---	---	---	---	---	---	---	---
K-40	---	---	---	---	---	---	---	---	---	---	---	---	---
Sc-46	3.50E-02	---	---	---	---	---	---	---	---	---	---	---	---
Cr-51	---	---	---	---	2.40E+04	3.74E+01	---	---	---	---	---	---	---
Mn-54	2.19E-01	2.62E+01	1.20E+00	---	4.39E+03	1.49E+01	5.59E+01	---	---	---	---	---	---
Fe-55	---	---	---	---	2.88E+05	2.98E+02	---	---	---	---	---	---	---
Fe-59	---	---	---	---	2.40E+04	3.73E+01	---	---	---	---	---	---	---
Co-57	2.12E+00	---	---	---	---	---	---	---	---	---	---	---	---
Co-58	---	---	---	---	6.50E+04	5.94E+02	---	---	---	---	---	---	---
Co-60	2.94E+00	1.88E+06	7.18E+04	---	3.14E+05	1.49E+02	1.66E+06	---	7.96E-03	4.63E-02	---	8.66E+00	1.38E+01
Ni-59	---	1.74E+03	7.96E+01	---	4.99E+03	4.46E-01	3.71E+03	---	7.67E-06	---	---	1.06E-01	5.66E-02
Ni-63	---	2.37E+05	1.09E+04	---	5.76E+05	4.46E+01	5.06E+05	---	7.67E-04	---	---	---	---
Zn-65	2.60E+00	---	---	---	---	---	---	---	---	---	---	---	---
Se-79	---	1.07E-01	6.66E-03	---	3.94E-03	2.23E-07	7.21E-01	---	1.25E-02	---	---	2.85E-02	6.46E-03
Sr-89	---	---	---	---	---	---	---	---	---	---	---	---	---
Sr-90	3.93E-02	1.81E+04	1.02E+03	---	1.69E+01	5.94E-02	1.10E+05	---	2.64E-02	2.88E-01	---	1.00E+02	1.47E+04
Y-90	---	---	---	---	1.69E+01	5.94E-02	---	---	---	---	---	7.63E+01	---
Zr-93	---	---	---	---	2.40E+04	2.98E-04	---	---	1.02E-05	---	---	1.16E-05	---
Zr-95	7.99E-01	---	---	---	1.98E+05	1.49E+01	---	---	---	---	---	---	---
Nb-93m	---	---	---	---	2.40E+04	2.23E+00	---	---	---	---	---	---	---
Nb-94	---	---	---	---	2.08E+01	2.98E-02	---	---	---	---	---	---	---
Nb-95	1.02E+00	---	---	---	4.19E+05	3.20E+01	---	---	---	---	---	---	---
Nb-95m	---	---	---	---	4.19E+03	---	---	---	---	---	---	---	---
Mo-93	---	---	---	---	4.61E+00	---	---	---	---	---	---	---	---
Tc-99	---	3.83E+00	2.39E-01	---	4.58E-01	1.49E-03	2.59E+01	---	2.53E+00	9.73E-04	---	3.41E-02	2.18E-01
Ru-103	4.14E-01	---	---	---	---	---	---	---	---	---	---	---	---
Ru-106	1.12E+00	---	---	---	1.34E+00	---	---	---	1.28E+00	---	---	1.66E-01	---
Rh-106	---	---	---	---	---	---	---	---	---	---	---	6.89E-04	---
Pd-107	---	---	---	---	---	---	---	---	7.67E-07	---	---	---	---
Ag-110m	---	---	---	---	---	---	---	---	2.27E-05	---	---	---	---
In-113m	---	---	---	---	1.56E+04	---	---	---	---	---	---	---	---
Sn-113	---	---	---	---	1.56E+04	---	---	---	---	---	---	---	---
Sn-119m	---	---	---	---	2.60E+05	---	---	---	---	---	---	---	---
Sn-121m	---	---	---	---	---	---	---	---	1.02E-03	---	---	---	---
Sn-123	---	---	---	---	7.55E+03	---	---	---	---	---	---	---	---
Sn-126	---	1.46E-01	9.14E-03	---	2.34E-05	6.70E-07	9.88E-01	---	5.12E-03	---	---	3.31E-04	8.58E-03
Sb-125	4.93E-02	1.55E+03	7.09E+01	---	1.31E+05	1.49E+00	3.30E+03	---	2.53E-01	---	---	---	---
Sb-126	---	---	---	---	---	---	---	---	5.12E-04	---	---	---	---
Sb-126m	---	---	---	---	---	---	---	---	---	---	---	---	---
Te-125m	---	7.16E+02	3.41E+01	---	8.16E+04	3.43E-01	1.88E+03	---	7.67E-03	---	---	---	---
Te-127	---	---	---	---	---	---	---	---	---	---	---	---	---
Te-127m	---	---	---	---	---	---	---	---	---	---	---	---	---
I-129	---	9.94E-02	6.21E-03	---	6.30E-06	5.94E-06	6.72E-01	---	7.67E-04	1.15E-06	---	4.43E-05	1.39E-04
Cs-134	5.56E-02	2.24E+03	1.40E+02	---	---	---	1.52E+04	---	2.53E-03	---	---	---	---
Cs-135	---	---	---	---	1.11E-04	---	---	---	1.51E-06	---	---	---	---
Cs-137	1.30E+00	2.29E+04	1.43E+03	---	1.66E+01	5.94E-02	1.55E+05	1.10E+01	1.02E+00	1.02E+01	4.50E+00	3.10E+02	2.52E+04
Ba-137m	---	---	---	---	1.66E+01	5.94E-02	---	---	---	---	---	7.08E+01	---
Ce-144	4.44E+00	---	---	---	1.58E+01	---	---	---	---	---	---	6.14E+00	---

F AREA

Radionuclide	235-F	772-F Lab	772-1F Lab	Canyon (Separations)	F-Area Tanks: Tank # 1-8	F-Area Tanks: Tank # 17-20	F-Area Tanks: Tank# 25-28 and 44-47	F-Area Tanks: Tank # 33-34	Naval Fuel Materials Facility	Inactive Process Sewer Lines	Sand Filters	Seepage Basin GW Op. Unit
Building Number	235-F	772-F	772-1F	221-F	Not Applicable	Not Applicable	Not Applicable	Not Applicable	247-F	081-F	294-F	Data Unavailable
Site Map Page No.	11, D-12	11, D11	11, B-8	12,G-5	13,G-6	13,E-4	13,G-4	13,I-6	11, B-10	Closed	11, E-10	Closed
Dates of Operation	Data Unavailable	Data Unavailable	Data Unavailable	Early 50s-2005	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	1955 - 1982	1975 - 1990	1954 - 1988
Total Volume	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	800 gal	5000 gal	8000 gal	200 gal	17,071 g	Data Unavailable	Data Unavailable	Data Unavailable
Reference No.	12	13	13	14	15, 16, 17	15, 16, 17	15, 16, 17	15, 16, 17	18	19	20	21
H-3	---	1.06E+01	1.00E-01	6.79E+01	---	---	---	---	---	1.11E+01	---	---
C-14	---	---	---	2.85E-01	1.15E-03	7.80E-03	3.34E-02	---	---	---	---	---
Na-22	---	---	---	---	---	---	---	---	---	---	---	---
Al-26	---	---	---	---	---	---	---	---	---	---	---	---
K-40	---	---	---	---	---	---	---	---	---	---	---	---
Sc-46	---	---	---	---	---	---	---	---	---	---	---	---
Cr-51	---	---	---	---	---	---	---	---	---	---	---	---
Mn-54	---	---	---	---	---	---	---	---	---	---	---	---
Fe-55	---	---	---	---	---	---	---	---	---	---	---	---
Fe-59	---	---	---	---	---	---	---	---	---	---	---	---
Co-57	---	---	---	---	---	---	---	---	---	---	---	---
Co-58	---	---	---	---	---	---	---	---	---	---	---	---
Co-60	---	---	---	1.14E+02	6.44E+01	6.15E+00	1.70E+02	2.89E+02	---	---	---	---
Ni-59	---	---	---	3.36E-01	1.07E+00	4.59E-01	1.96E+00	4.35E-01	---	---	---	---
Ni-63	---	---	---	---	0.00E+00	0.00E+00	0.00E+00	0.00E+00	---	---	---	---
Zn-65	---	---	---	---	---	---	---	---	---	---	---	---
Se-79	---	3.25E-06	2.63E-07	7.64E-02	7.23E-01	3.79E-02	1.62E-01	3.12E-01	---	---	---	---
Sr-89	---	---	---	---	---	---	---	---	---	---	---	---
Sr-90	---	4.96E-01	4.01E-02	9.29E+03	3.48E+04	2.10E+03	1.29E+04	2.43E+04	---	5.22E+01	---	1.03E+00
Y-90	---	---	---	9.29E+03	3.48E+04	2.10E+03	1.29E+04	2.43E+04	---	---	---	---
Zr-93	---	---	---	---	---	---	---	---	---	---	---	---
Zr-95	---	---	---	---	---	---	---	---	---	---	---	---
Nb-93m	---	---	---	---	---	---	---	---	---	---	---	---
Nb-94	---	---	---	---	---	---	---	---	---	---	---	---
Nb-95	---	---	---	---	---	---	---	---	---	---	---	---
Nb-95m	---	---	---	---	---	---	---	---	---	---	---	---
Mo-93	---	---	---	---	---	---	---	---	---	---	---	---
Tc-99	---	1.17E-04	9.44E-06	2.85E+00	1.25E+01	6.58E-01	2.81E+00	5.39E+00	---	2.21E-01	---	8.80E-02
Ru-103	---	---	---	---	---	---	---	---	---	---	---	---
Ru-106	---	---	3.63E-04	5.95E+02	1.46E-01	5.53E-03	3.05E+02	3.15E+02	---	2.21E-01	1.02E+01	---
Rh-106	---	4.50E-03	---	5.95E+02	1.46E-01	5.53E-03	3.05E+02	3.15E+02	---	---	---	---
Pd-107	---	---	---	---	---	---	---	---	---	---	---	---
Ag-110m	---	---	---	---	---	---	---	---	---	---	---	---
In-113m	---	---	---	---	---	---	---	---	---	---	---	---
Sn-113	---	---	---	---	---	---	---	---	---	---	---	---
Sn-119m	---	---	---	---	---	---	---	---	---	---	---	---
Sn-121m	---	---	---	---	---	---	---	---	---	---	---	---
Sn-123	---	---	---	---	---	---	---	---	---	---	---	---
Sn-126	---	4.46E-06	3.61E-07	9.17E-03	1.35E+00	7.05E-02	3.01E-01	5.80E-01	---	---	---	---
Sb-125	---	5.72E-07	4.62E-08	---	3.71E+01	4.00E+00	5.74E+02	8.72E+02	---	---	---	---
Sb-126	---	---	---	---	---	---	---	---	---	---	---	---
Sb-126m	---	---	---	---	---	---	---	---	---	---	---	---
Te-125m	---	2.30E-03	1.86E-04	---	---	---	---	---	---	---	---	---
Te-127	---	---	---	---	---	---	---	---	---	---	---	---
Te-127m	---	---	---	---	---	---	---	---	---	---	---	---
I-129	---	3.03E-06	2.45E-07	5.20E-03	5.96E-05	3.12E-06	1.33E-05	2.57E-05	---	---	---	3.57E-02
Cs-134	---	6.85E-02	5.53E-03	---	1.87E-01	1.82E-02	7.95E+00	1.12E+01	---	---	---	---
Cs-135	---	---	---	---	8.28E-03	4.34E-04	1.85E-03	3.57E-03	---	---	---	---
Cs-137	---	7.00E-01	5.65E-02	1.73E+04	2.42E+03	1.45E+02	8.72E+02	1.64E+03	---	6.92E+01	4.81E+03	1.49E+01
Ba-137m	---	---	---	1.64E+04	2.29E+03	1.37E+02	8.25E+02	1.56E+03	---	---	---	---
Ce-144	---	1.23E-03	9.97E-05	7.09E+02	1.60E-02	3.21E-04	3.84E+02	3.57E+02	---	---	4.16E+00	---

Residual Radionuclide Summary

E Area

RADIONUCLIDE	Lysimeters	MWMF		Naval Fuel Waste	Naval Reactors KAPL CB/TS	Naval Reactors KAPL Head	Old Burial Ground	Old Solvent Tanks S1-S22	Saltstone Lysimeters	E-Area Trenches	Solvent Tanks S23-S30 and S32	Vaults LAW	Vaults ILV
Pr-144	—	—	—	—	—	—	—	—	—	—	—	5.96E+00	—
Pr-144m	—	—	—	—	—	—	—	—	—	—	—	2.99E-05	—
Pm-147	—	—	—	—	9.54E+00	—	—	—	1.53E-01	—	—	3.31E+01	—
Sm-151	—	3.11E+02	1.94E+01	—	1.73E-01	—	2.10E+03	—	7.67E-02	—	—	—	—
Eu-152	—	—	—	—	—	—	—	—	2.27E-04	—	—	—	—
Eu-154	4.80E-03	1.21E+03	7.58E+01	—	2.16E-01	—	8.20E+03	—	2.53E-02	1.53E-02	—	—	—
Eu-155	—	4.37E+01	2.73E+00	—	1.23E-01	—	2.95E+02	—	1.25E-02	—	—	—	—
Hf-181	—	—	—	—	2.40E+04	1.49E+01	—	—	—	—	—	—	—
Ta-182	—	—	—	—	5.66E+04	8.42E-02	—	—	—	—	—	—	—
Pb-212	—	—	—	—	—	—	—	—	—	9.35E-03	—	—	—
Pb-214	—	—	—	—	—	—	—	—	—	—	—	—	—
Bi-214	—	—	—	—	—	—	—	—	—	—	—	—	—
Ra-226	—	—	—	—	—	—	—	—	—	—	—	—	—
Ra-228	—	—	—	—	—	—	—	—	—	—	—	—	—
Ac-228	—	—	—	—	—	—	—	—	—	—	—	—	—
Th-228	—	—	—	—	—	—	—	—	5.12E-08	—	—	—	—
Th-230	—	—	—	—	—	—	—	—	—	—	—	—	—
Th-231	—	—	—	—	—	—	—	—	5.12E-06	—	—	—	—
Th-232	—	2.46E+00	1.46E+00	—	8.51E-11	1.42E-10	3.61E+00	—	—	—	—	3.17E-02	—
Th-234	—	—	—	—	—	—	—	—	7.67E-08	—	—	—	—
Pa-234	—	—	—	—	—	—	—	—	1.51E-07	—	—	—	—
U-232	—	—	—	—	1.39E-06	2.23E-06	—	—	1.76E-06	—	—	2.48E-05	—
U-233	—	1.55E+00	4.90E-01	—	—	—	2.33E-01	—	1.02E-07	—	—	1.75E-03	2.56E-04
U-234	—	2.79E+01	2.25E+01	4.46E+00	8.90E-06	—	1.98E+01	—	1.02E-05	—	—	7.79E-01	1.12E-04
U-235	—	1.06E+00	4.99E-01	8.81E-02	6.59E-07	—	6.14E-01	—	—	—	—	1.23E-02	3.00E-06
U-236	—	4.70E+00	1.18E+00	1.41E-04	1.35E-05	—	2.85E+00	—	—	—	—	3.59E-02	5.84E-06
U-238	—	4.16E+01	4.63E+00	—	7.46E-05	—	1.57E+01	—	7.67E-08	—	—	6.29E-02	1.55E-04
Np-237	—	9.57E-02	1.68E-04	—	1.29E-05	4.46E-09	1.57E+00	—	2.27E-06	8.85E-07	—	8.69E-03	1.75E-03
Np-239	—	—	—	—	—	—	—	—	—	—	—	—	—
Pu-236	—	—	—	—	—	—	—	—	—	—	—	—	—
Pu-238	3.38E+00	3.97E+03	3.05E+02	—	8.61E-01	3.73E-04	1.62E+04	2.75E+02	1.90E-03	5.16E-03	1.13E+02	6.01E+00	1.43E+01
Pu-239	1.80E+00	6.09E+01	9.03E-01	—	3.97E-01	5.94E-05	1.30E+03	5.50E+01	5.17E-03	—	2.25E+01	1.54E+00	2.15E+00
Pu-240	—	1.51E+01	2.67E-01	—	3.55E-01	3.73E-05	3.11E+02	—	1.25E-05	—	—	3.04E-01	4.60E-02
Pu-241	—	6.14E+02	1.30E+01	—	1.09E+02	1.49E-02	1.19E+04	—	1.25E-03	—	—	1.52E+01	3.68E+00
Pu-242	—	1.25E-03	—	—	1.30E-03	4.46E-07	—	—	—	—	—	3.00E-05	7.66E-05
Pu-244	—	—	—	—	8.87E-11	6.70E-14	—	—	—	—	—	2.59E-15	—
Am-241	9.27E-04	2.01E+01	1.97E-01	—	1.13E+00	5.21E-04	2.30E+02	—	5.12E-03	2.57E-01	—	3.01E-01	4.38E+00
Am-242	—	—	—	—	—	—	—	—	2.53E-06	—	—	—	—
Am-242m	—	—	—	—	7.17E-06	2.98E-06	—	—	2.53E-06	—	—	—	—
Am-243	—	—	9.95E-04	—	7.71E-03	4.46E-06	—	—	1.51E-06	—	—	1.73E-07	—
Cm-242	—	—	—	—	1.67E+01	9.67E-03	—	—	2.53E-06	—	—	—	—
Cm-243	—	—	—	—	2.24E-06	3.73E-06	—	—	1.02E-06	—	—	—	—
Cm-244	—	1.82E+04	3.79E+03	—	6.14E-01	5.21E-04	2.54E+04	2.20E+02	2.53E-05	—	9.00E+01	—	—
Cm-245	—	—	—	—	3.27E-05	3.73E-08	—	—	—	—	—	1.45E-09	—
Cm-246	—	—	—	—	1.26E-05	1.49E-08	—	—	—	—	—	5.77E-10	—
Cm-247	—	—	—	—	2.53E-11	4.46E-14	—	—	—	—	—	6.14E-12	—
Cm-248	—	—	—	—	5.96E-11	1.42E-13	—	—	—	—	—	5.50E-15	—
Cf-249	—	—	—	—	3.97E-10	7.46E-13	—	—	—	—	—	2.88E-14	—
Cf-251	—	—	—	—	8.47E-12	2.98E-14	—	—	—	—	—	1.40E-09	—
Cf-252	—	1.79E+01	3.39E+01	—	—	—	7.53E+00	—	—	—	—	—	—

F AREA

235-F	772-F Lab	772-1F Lab	Canyon (Separations)	F-Area Tanks: Tank # 1-8	F-Area Tanks: Tank # 17-20	F-Area Tanks: Tank# 25-28 and 44-47	F-Area Tanks: Tank # 33-34	Naval Fuel Materials Facility	Inactive Process Sewer Lines	Sand Filters	Seepage Basin GW Op. Unit	
—	—	—	7.09E-02	1.60E-02	3.21E-04	3.84E+02	3.57E+02	—	—	—	—	Pr-144
—	—	—	1.02E-01	—	—	—	—	—	—	—	—	Pr-144m
—	6.34E-02	5.12E-03	8.16E-03	6.32E+02	6.78E+01	1.12E+04	1.68E+04	—	—	—	—	Pm-147
—	9.48E-03	7.66E-04	—	—	—	—	—	—	—	—	—	Sm-151
—	—	—	—	—	—	—	—	—	3.81E-02	—	—	Eu-152
—	3.70E-02	2.99E-03	—	1.28E+02	1.01E+01	1.35E+02	2.43E+02	—	—	—	—	Eu-154
—	1.33E-03	1.08E-04	—	—	—	—	—	—	7.63E-03	—	—	Eu-155
—	—	—	—	—	—	—	—	—	—	—	—	Hf-181
—	—	—	—	—	—	—	—	—	—	—	—	Ta-182
—	—	—	—	—	—	—	—	—	—	—	—	Pb-212
—	—	—	—	—	—	—	—	—	—	—	—	Pb-214
—	—	—	—	—	—	—	—	—	—	—	—	Bi-214
—	—	—	—	—	—	—	—	—	8.72E-02	—	—	Ra-226
—	—	—	—	—	—	—	—	—	—	—	—	Ra-228
—	—	—	—	—	—	—	—	—	—	—	—	Ac-228
—	—	—	—	—	—	—	—	—	—	—	—	Th-228
—	—	—	—	—	—	—	—	—	—	—	—	Th-230
—	—	—	—	—	—	—	—	—	—	—	—	Th-231
—	—	—	—	—	—	—	—	—	6.59E-02	—	—	Th-232
—	—	—	—	—	—	—	—	—	—	—	—	Th-234
—	—	—	—	—	—	—	—	—	—	—	—	Pa-234
—	—	—	—	6.22E-04	1.17E-04	5.82E-04	3.22E-04	—	—	—	—	U-232
—	—	—	4.97E-08	—	—	—	—	—	—	—	—	U-233
—	—	—	4.70E-02	—	—	—	—	1.82E+00	7.90E-02	—	5.58E-02	U-234
—	—	—	8.62E-04	9.80E-04	7.88E-04	1.23E-03	3.24E-04	3.59E-02	—	—	1.96E-02	U-235
—	—	—	9.38E-03	—	—	—	—	—	—	—	—	U-236
—	—	—	1.68E-02	3.04E-02	5.07E-02	1.13E-01	2.63E-02	5.74E-05	8.99E-01	—	9.81E-02	U-238
1.20E+01	—	—	3.53E-03	5.25E-02	—	—	2.11E-02	—	2.15E-02	—	—	Np-237
—	—	—	—	—	—	—	—	—	—	—	—	Np-239
—	—	—	—	—	—	—	—	—	—	—	—	Pu-236
1.02E+04	2.07E-01	1.63E-03	1.25E+01	—	—	—	—	—	2.72E-01	—	4.44E-01	Pu-238
—	1.23E-02	2.75E-03	1.56E+02	8.10E+00	3.01E+01	1.38E+02	3.62E+00	—	7.57E+00	2.35E+01	1.75E+00	Pu-239
—	2.90E-03	6.51E-04	3.60E+01	1.93E+00	7.51E+00	3.09E+01	8.08E-01	—	—	—	—	Pu-240
—	1.91E+00	5.25E-01	1.95E+03	5.81E+00	4.26E+02	6.83E+02	1.70E+01	—	—	—	—	Pu-241
—	—	—	2.43E-03	1.15E-03	1.16E-02	6.36E-03	1.67E-04	—	—	—	—	Pu-242
—	—	—	—	—	—	—	—	—	—	—	—	Pu-244
—	2.18E-03	4.90E-04	1.58E+00	1.12E+02	7.17E+01	4.19E+02	5.37E+01	—	3.00E-02	—	3.29E-02	Am-241
—	—	—	—	—	—	—	—	—	—	—	—	Am-242
—	—	—	1.98E-02	1.22E-01	—	—	5.87E-02	—	—	—	—	Am-242m
—	—	—	1.94E+00	—	—	—	—	—	—	—	—	Am-243
—	—	—	—	—	—	—	—	—	—	—	—	Cm-242
—	—	—	—	—	—	—	—	—	—	—	—	Cm-243
—	—	—	2.11E+02	2.86E-02	1.84E-03	1.39E-02	2.60E-02	—	5.72E-02	—	—	Cm-244
—	—	—	1.72E-02	2.05E-08	1.09E-09	4.64E-09	8.84E-09	—	—	—	—	Cm-245
—	—	—	2.69E-02	—	—	—	—	—	—	—	—	Cm-246
—	—	—	1.27E-07	—	—	—	—	—	—	—	—	Cm-247
—	—	—	—	—	—	—	—	—	—	—	—	Cm-248
—	—	—	—	—	—	—	—	—	—	—	—	Cf-249
—	—	—	—	—	—	—	—	—	—	—	—	Cf-251
—	—	—	—	—	—	—	—	—	—	—	—	Cf-252

Residual Radionuclide Summary

		H AREA												S Area		Z Area	Various Spills									
					H-Area Tanks																					
		Canyon (Separations)	ETF Receipt Tank	Inactive Process Sewer Lines	Tank # 9-12	Tank #13-16	Tank # 21-24, 29-32, and 35-37	Tank # 38-43	Tank # 48-51	New Solvent Tanks H33-H36	Sand Filter	Seepage Basin GW Op. Unit	Tritium Processing	DWPF	Low Point Pump Pit	Saltstone Vaults	Spill at Tank 13	Spill at Tank 9	Spill at Tank 16	Spill at Tank 37	Spill at B281-3F	Spill at Tank 3	Spill at Tank 8	Spill at B281-3H	Soil and Debris Consol. Facility	
	Building Number	221-H	241-H	081-H	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Data Unavailable	294-H	Data Unavailable	232H,233H, 234H	292-S	511-S	451-1,6,7	Tank 13	Tank 9	Tank 16	Tank 37	B281-3F	Tank 3	Tank 8	B281-3H	TBA	
	Site Map Page No.	15,F-5	16,F-8 17,G-11	Closed	16,F-12	17,A-5	14,F-6	14,H-9	14,I-9	14,D-12	15,H-10	Closed	15,C-1	19,F-4	19,J-5	20, G-8	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	
	Dates of Operation	Early 50s-2005	1977- Present	1955 - 1982	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	1997 - 2028	1975 - 1990	1954 - 1988	1955 - 2005	1996-2038	1996-2038	1992 - 2038	Dec-83	May-67	Sep-60	Feb-89	Startup - 1973	Aug-75	Apr-61	Startup - 1973	TBA	
	Total Volume	Data Unavailable	1000 L	Data Unavailable	400 gal	400 gal	2000 gal	600 gal	1300 gal	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	1000 gal	50 gal	Data Unavailable	100 gal	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	Data Unavailable	562,500 yd^3	
	Reference No.	14	22	6	15, 16, 17	15, 16, 17	15, 16, 17	15, 16, 17	15, 16, 17	10	20	21	23	24	24	22	25, 26	25, 26	25	27, 28	26	25	25, 26	26	29	Radionuclide
	H-3	1.02E+00	7.00E-02	2.87E+01	---	---	---	---	---	---	---	---	3.00E+04	6.34E-02	3.17E-03	1.90E+04	---	---	5.00E-02	8.41E-02	---	---	---	---	3.71E-02	H-3
	C-14	4.28E-03	---	---	7.97E-04	2.88E-04	8.79E-04	5.85E-04	2.08E-04	---	---	---	---	---	---	6.50E+00	---	---	---	---	---	---	---	---	9.06E-02	C-14
	Na-22	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Na-22
	Al-26	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Al-26
	K-40	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1.50E-02	K-40
	Sc-46	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Sc-46
	Cr-51	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Cr-51
	Mn-54	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Mn-54
	Fe-55	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Fe-55
	Fe-59	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Fe-59
	Co-57	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Co-57
	Co-58	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Co-58
	Co-60	1.71E+00	1.00E-04	5.15E-01	4.78E+01	2.47E+01	4.36E+02	3.22E+02	7.10E-01	---	---	---	---	2.94E+02	1.47E+01	2.00E+02	---	---	---	---	---	---	---	---	8.99E-03	Co-60
	Ni-59	5.04E-03	---	---	5.30E-01	4.45E-01	8.87E-01	4.02E-01	1.37E-02	---	---	---	---	2.39E+00	1.20E-01	2.00E-01	---	---	---	---	---	---	---	---	2.87E-03	Ni-59
	Ni-63	---	---	---	---	---	---	---	---	---	---	---	---	2.97E+02	1.49E+01	2.00E+01	---	---	---	---	---	---	---	---	---	Ni-63
	Zn-65	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Zn-65
	Se-79	1.15E-03	---	---	3.09E-01	2.75E-01	5.10E-01	2.31E-01	2.11E-03	---	---	---	---	2.34E-01	1.17E-02	3.20E+02	---	---	---	---	---	---	---	---	7.03E-08	Se-79
	Sr-89	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Sr-89
	Sr-90	1.39E+02	4.00E-04	1.94E+01	1.67E+04	1.40E+04	3.92E+04	2.08E+04	1.41E+02	---	---	5.35E+01	---	5.17E+04	2.59E+03	6.80E+02	---	---	2.00E+00	3.36E+00	---	---	---	---	7.96E-01	Sr-90
	Y-90	1.39E+02	---	---	1.67E+04	1.40E+04	3.92E+04	2.08E+04	1.41E+02	---	---	---	---	5.32E+04	2.66E+03	---	---	---	---	---	---	---	---	---	---	Y-90
	Zr-93	---	---	---	---	---	---	---	---	---	---	---	---	1.94E+00	9.70E-02	2.60E-01	---	---	---	---	---	---	---	---	---	Zr-93
R	Zr-95	---	---	---	---	---	---	---	---	---	---	---	---	1.74E-02	8.70E-04	---	---	---	---	---	---	---	---	---	1.26E-04	Zr-95
A	Nb-93m	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Nb-93m
D	Nb-94	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Nb-94
I	Nb-95	---	---	---	---	---	---	---	---	---	---	---	---	3.67E-02	1.84E-03	---	---	---	---	---	---	---	---	---	---	Nb-95
O	Nb-95m	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Nb-95m
N	Mo-93	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Mo-93
U	Tc-99	4.28E-02	---	---	5.29E+00	4.70E+00	8.65E+00	3.92E+00	3.62E-02	---	---	6.31E-01	---	4.26E+00	2.13E-01	6.50E+04	---	---	---	---	---	---	---	---	1.02E-03	Tc-99
C	Ru-103	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Ru-103
L	Ru-106	8.92E+00	5.00E-03	---	8.02E-03	4.75E-04	2.36E+01	4.63E+01	1.04E-03	---	1.02E+01	---	---	2.69E+03	1.35E+02	3.30E+04	---	---	---	---	---	---	---	---	---	Ru-106
I	Rh-106	8.92E+00	---	---	8.02E-03	4.76E-04	2.36E+01	4.63E+01	1.04E-03	---	---	---	---	2.64E+03	1.32E+02	---	---	---	---	---	---	---	---	---	---	Rh-106
D	Pd-107	---	---	---	---	---	---	---	---	---	---	---	---	1.57E-02	7.85E-04	2.00E-02	---	---	---	---	---	---	---	---	---	Pd-107
E	Ag-110m	---	---	---	---	---	---	---	---	---	---	---	---	2.25E+01	1.13E+00	5.80E-01	---	---	---	---	---	---	---	---	---	Ag-110m
	In-113m	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	In-113m
	Sn-113	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Sn-113
	Sn-119m	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Sn-119m
	Sn-121m	---	---	---	---	---	---	---	---	---	---	---	---	5.13E-02	2.57E-03	2.60E+01	---	---	---	---	---	---	---	---	---	Sn-121m
	Sn-123	---	---	---	---	---	---	---	---	---	---	---	---	4.55E-01	2.28E-02	---	---	---	---	---	---	---	---	---	---	Sn-123
	Sn-126	1.38E-04	---	---	4.12E-01	3.66E-01	5.16E-01	2.13E-01	2.89E-03	---	---	---	---	2.58E-01	1.29E-02	1.30E+02	---	---	---	---	---	---	---	---	8.50E-09	Sn-126
	Sb-125	---	6.00E-05	---	4.85E+00	1.61E+00	1.90E+02	1.78E+02	2.37E-01	---	---	---	---	1.43E+03	7.15E+01	6.50E+03	---	---	---	---	---	---	---	---	---	Sb-125
	Sb-126	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1.30E+01	---	---	---	---	---	---	---	---	---	Sb-126
	Sb-126m	---	---	---	---	---	---	---	---	---	---	---	---	2.60E-01	1.30E-02	---	---	---	---	---	---	---	---	---	---	Sb-126m
	Te-125m	---	6.00E-05	---	---	---	---	---	---	---	---	---	---	3.42E+02	1.71E+01	2.00E+02	---	---	---	---	---	---	---	---	---	Te-125m
	Te-127	---	---	---	---	---	---	---	---	---	---	---	---	1.49E-01	7.45E-03	---	---	---	---	---	---	---	---	---	---	Te-127
	Te-127m	---	---	---	---	---	---	---	---	---	---	---	---	1.53E-01	7.65E-03	---	---	---	---	---	---	---	---	---	---	Te-127m
	I-129	7.79E-05	2.70E-05	1.28E-01	2.14E-05	1.90E-05	3.11E-05	1.36E-05	1.48E-07	---	---	1.54E+00	---	1.24E-02	6.20E-04	2.00E+01	---	---	---	---	---	---	---	---	1.30E-09	I-129
	Cs-134	---	---	6.54E-02	3.98E-01	7.70E-02	4.21E+01	4.27E+01	1.97E-02	---	---	---	---	3.03E+02	1.52E+01	8.50E+01	---	---	---	---	---	---	---	---	---	Cs-134
	Cs-135	---	---	---	3.50E-03	3.11E-03	5.72E-03	2.59E-03	2.39E-05	---	---	---	---	---	---	3.90E-02	---	---	---	---	---	---	---	---	---	Cs-135
	Cs-137	2.60E+02	6.00E-03	6.97E+00	4.60E+02	8.46E+02	2.15E+03	1.12E+03	8.40E+00	4.00E+01	4.81E+03	1.51E+02	---	2.86E+03	1.43E+02	2.65E+04	3.15E+02	5.53E+01	8.30E+02	1.40E+03	1.00E+01	3.72E+01	2.67E+03	3.00E+01	2.98E+00	Cs-137
	Ba-137m	2.46E+02	---	---	9.43E+02	8.00E+02	2.03E+03	1.06E+03	7.94E+00	---	---	---	---	2.70E+03	1.35E+02	---	---	---	---	---	---	---	---	---	---	Ba-137m
	Ce-144	1.06E+01	---	---	4.29E-03	2.05E-04	6.05E+01	2.45E+02	5.05E-04	---	4.16E+00	---	---	1.69E+04	8.45E+02	3.20E+00	---	---	---	---	---	---	---	---	---	Ce-144

Residual Radionuclide Summary

RADIONUCLIDE	H AREA: Canyon (Separations)	H AREA: ETF Receipt Tank	H AREA: Inactive Process Sewer Lines	H-Area Tanks: Tank # 9-12	H-Area Tanks: Tank #13-16	H-Area Tanks: Tank # 21-24, 29-32, and 35-37	H-Area Tanks: Tank # 38-43	H-Area Tanks: Tank # 48-51	H AREA: New Solvent Tanks H33-H36	H AREA: Sand Filter	H AREA: Seepage Basin GW Op. Unit	H AREA: Tritium Processing
Pr-144	1.06E+01	---	---	4.29E-03	2.05E-04	6.05E+01	2.45E+02	5.05E-04	---	---	---	---
Pr-144m	1.53E-01	---	---	---	---	---	---	---	---	---	---	---
Pm-147	1.22E+02	5.00E-04	---	1.30E+02	3.84E+01	5.86E+03	5.55E+03	5.83E+00	---	---	---	---
Sm-151	---	---	---	---	---	---	---	---	---	---	---	---
Eu-152	---	---	---	---	---	---	---	---	---	---	---	---
Eu-154	---	---	---	1.72E+02	1.10E+02	8.80E+02	5.98E+02	2.04E+00	---	---	---	---
Eu-155	---	---	---	---	---	---	---	---	---	---	---	---
Hf-181	---	---	---	---	---	---	---	---	---	---	---	---
Ta-182	---	---	---	---	---	---	---	---	---	---	---	---
Pb-212	---	---	---	---	---	---	---	---	---	---	---	---
Pb-214	---	---	---	---	---	---	---	---	---	---	---	---
Bi-214	---	---	---	---	---	---	---	---	---	---	---	---
Ra-226	---	---	7.63E-02	---	---	---	---	---	---	---	---	---
Ra-228	---	---	---	---	---	---	---	---	---	---	---	---
Ac-228	---	---	---	---	---	---	---	---	---	---	---	---
Th-228	---	---	---	---	---	---	---	---	---	---	---	---
Th-230	---	---	---	---	---	---	---	---	---	---	---	---
Th-231	---	---	---	---	---	---	---	---	---	---	---	---
Th-232	---	---	7.38E-02	8.70E-04	1.12E-03	2.12E-04	2.82E-04	5.55E-09	---	---	---	---
Th-234	---	---	---	---	---	---	---	---	---	---	---	---
Pa-234	---	---	---	---	---	---	---	---	---	---	---	---
U-232	---	---	---	1.10E-04	9.65E-05	4.25E-05	4.55E-06	3.06E-06	---	---	---	---
U-233	7.46E-10	---	---	2.60E-02	3.01E-02	5.60E-02	4.96E-03	3.86E-04	---	---	---	---
U-234	4.44E-02	---	1.91E-01	3.80E-03	5.49E-03	2.57E-02	1.60E-02	2.45E-04	---	---	1.53E-01	---
U-235	8.42E-04	---	---	2.29E-04	1.91E-04	4.94E-04	2.64E-04	2.68E-05	---	---	1.06E-01	---
U-236	9.54E-03	---	---	4.17E-04	5.22E-04	5.43E-03	3.60E-03	4.71E-05	---	---	---	---
U-238	2.80E-05	---	1.91E-01	4.42E-03	2.51E-03	2.13E-03	1.74E-03	1.16E-03	---	---	1.35E-01	---
Np-237	3.56E-01	---	---	3.44E-02	2.04E-02	2.45E-02	9.70E-03	1.50E-04	---	---	---	---
Np-239	---	---	---	2.28E+02	5.74E+01	2.06E+03	8.15E+02	1.31E+00	---	---	---	---
Pu-236	---	---	---	---	---	---	---	---	---	---	---	---
Pu-238	1.02E+03	4.00E-05	3.27E-01	2.02E+02	5.08E+01	1.82E+03	7.22E+02	1.16E+00	5.00E+01	2.35E-01	1.16E+00	---
Pu-239	6.90E+00	1.00E-05	5.50E+00	4.30E+00	2.78E+00	1.66E+01	7.95E+00	7.14E-01	1.00E+01	---	4.06E+00	---
Pu-240	3.10E+00	---	---	1.99E+00	1.07E+00	1.19E+01	4.97E+00	1.82E-01	---	---	---	---
Pu-241	1.06E+02	---	---	3.90E+01	4.79E+00	8.37E+02	4.14E+02	1.07E+00	---	---	---	---
Pu-242	3.15E-02	---	---	3.07E-03	5.10E-04	2.59E-02	1.16E-02	2.12E-04	---	---	---	---
Pu-244	---	---	---	---	---	---	---	---	---	---	---	---
Am-241	---	---	2.07E-01	1.08E+02	4.53E+01	7.72E+02	3.40E+02	2.33E+00	---	---	3.93E-01	---
Am-242	---	---	---	---	---	---	---	---	---	---	---	---
Am-242m	---	---	---	3.83E-02	3.40E-02	5.21E-02	2.13E-02	7.84E-05	---	---	---	---
Am-243	---	---	---	---	---	---	---	---	---	---	---	---
Cm-242	---	---	---	---	---	---	---	---	---	---	---	---
Cm-243	---	---	---	---	---	---	---	---	---	---	---	---
Cm-244	---	---	2.72E-02	1.14E-01	8.50E-02	4.03E-01	2.37E-01	9.67E-04	4.00E+01	---	---	---
Cm-245	---	---	---	1.04E-05	9.19E-06	2.75E-05	1.38E-05	6.59E-08	---	---	---	---
Cm-246	---	---	---	---	---	---	---	---	---	---	---	---
Cm-247	---	---	---	---	---	---	---	---	---	---	---	---
Cm-248	---	---	---	---	---	---	---	---	---	---	---	---
Cf-249	---	---	---	---	---	---	---	---	---	---	---	---
Cf-251	---	---	---	---	---	---	---	---	---	---	---	---
Cf-252	---	---	---	---	---	---	---	---	---	---	---	---

RADIONUCLIDE	S Area: DWPF	S Area: Low Point Pump Pit	Z Area: Saltstone Vaults	Various Spills: Spill at Tank 13	Various Spills: Spill at Tank 9	Various Spills: Spill at Tank 16	Various Spills: Spill at Tank 37	Various Spills: Spill at B281-3F	Various Spills: Spill at Tank 3	Various Spills: Spill at Tank 8	Various Spills: Spill at B281-3H	Soil and Debris Consol. Facility
Pr-144	1.69E+04	8.45E+02	---	---	---	---	---	---	---	---	---	---
Pr-144m	2.04E+02	1.02E+01	---	---	---	---	---	---	---	---	---	---
Pm-147	4.15E+04	2.08E+03	3.90E+03	---	---	---	---	---	---	---	---	---
Sm-151	4.19E+02	2.10E+01	2.00E+03	---	---	---	---	---	---	---	---	---
Eu-152	8.37E+00	3.19E-01	5.80E+00	---	---	---	---	---	---	---	---	---
Eu-154	1.07E+03	5.35E+01	6.50E+02	---	---	---	---	---	---	---	---	9.70E-04
Eu-155	8.21E+02	4.11E+01	3.20E+02	---	---	---	---	---	---	---	---	1.86E-03
Hf-181	---	---	---	---	---	---	---	---	---	---	---	---
Ta-182	---	---	---	---	---	---	---	---	---	---	---	---
Pb-212	---	---	---	---	---	---	---	---	---	---	---	5.70E-03
Pb-214	---	---	---	---	---	---	---	---	---	---	---	---
Bi-214	---	---	---	---	---	---	---	---	---	---	---	---
Ra-226	---	---	---	---	---	---	---	---	---	---	---	3.12E-03
Ra-228	---	---	---	---	---	---	---	---	---	---	---	4.86E-03
Ac-228	---	---	---	---	---	---	---	---	---	---	---	7.82E-03
Th-228	---	---	1.30E-03	---	---	---	---	---	---	---	---	1.04E-02
Th-230	---	---	---	---	---	---	---	---	---	---	---	8.48E-03
Th-231	---	---	1.30E-01	---	---	---	---	---	---	---	---	---
Th-232	---	---	---	---	---	---	---	---	---	---	---	6.14E-03
Th-234	---	---	2.00E-03	---	---	---	---	---	---	---	---	---
Pa-234	---	---	3.90E-03	---	---	---	---	---	---	---	---	---
U-232	1.46E-01	7.30E-03	4.50E-02	---	---	---	---	---	---	---	---	---
U-233	---	---	2.60E-03	---	---	---	---	---	---	---	---	1.27E-03
U-234	4.60E-01	2.30E-02	2.60E-01	---	---	---	---	---	---	---	---	8.54E-02
U-235	---	---	---	---	---	---	---	---	---	---	---	7.54E-03
U-236	3.34E-02	1.67E-03	---	---	---	---	---	---	---	---	---	1.51E-07
U-238	---	---	2.00E-03	---	---	---	---	---	---	---	---	8.66E-02
Np-237	1.52E-02	7.60E-04	5.80E-02	---	---	---	---	---	---	---	---	4.97E-08
Np-239	---	---	---	---	---	---	---	---	---	---	---	---
Pu-236	1.06E-01	5.30E-03	---	---	---	---	---	---	---	---	---	---
Pu-238	1.29E+03	6.45E+01	4.90E+01	---	---	---	---	---	---	---	---	2.55E-02
Pu-239	1.21E+01	6.05E-01	1.31E+02	---	---	2.00E-01	3.36E-01	---	---	---	---	2.97E-01
Pu-240	7.70E+00	3.85E-01	3.20E-01	---	---	---	---	---	---	---	---	1.62E-03
Pu-241	1.45E+03	7.25E+01	3.20E+01	---	---	---	---	---	---	---	---	4.82E-03
Pu-242	1.06E-02	5.30E-04	---	---	---	---	---	---	---	---	---	1.13E-08
Pu-244	---	---	---	---	---	---	---	---	---	---	---	---
Am-241	1.86E+01	9.30E-01	1.30E+02	---	---	---	---	---	---	---	---	4.18E-02
Am-242	2.45E-02	1.23E-03	6.50E-02	---	---	---	---	---	---	---	---	---
Am-242m	2.47E-02	1.24E-03	6.50E-02	---	---	---	---	---	---	---	---	---
Am-243	---	---	3.90E-02	---	---	---	---	---	---	---	---	---
Cm-242	6.03E-02	3.02E-03	6.50E-02	---	---	---	---	---	---	---	---	---
Cm-243	---	---	2.60E-02	---	---	---	---	---	---	---	---	---
Cm-244	2.80E-01	1.40E-02	6.50E-01	---	---	---	---	---	---	---	---	---
Cm-245	---	---	---	---	---	---	---	---	---	---	---	---
Cm-246	---	---	---	---	---	---	---	---	---	---	---	---
Cm-247	---	---	---	---	---	---	---	---	---	---	---	---
Cm-248	---	---	---	---	---	---	---	---	---	---	---	---
Cf-249	---	---	---	---	---	---	---	---	---	---	---	---
Cf-251	---	---	---	---	---	---	---	---	---	---	---	---
Cf-252	---	---	---	---	---	---	---	---	---	---	---	---

References Used for the Residual Radionuclide Summary

1 - Hooker and Root 1981
2 - Cook 1989
3 - Cook 1996a
4 - Cook 1996b
5 - WSRC 1994
6 - Cole 1996a
7 - WSRC 1992a
8 - WSRC 1994
9 - Sink 1996
10 - Shappell 1996
11 - Purcell 1996
12 - Lux 1997
13 - WSRC 1996a
14 - WSRC 1996b
15 - Hestos 1996a
16 - Hestos 1996b
17 - D'Entremont 1997
18 - WSRC 1997a
19 - WSRC 1996c
20 - Sykes and Harper 1968
21 - Cole 1996b
22 - WSRC 1992
23 - Hsu 1996
24 - WSRC 1995
25 - D'Entremont 1988
26 - Stephens and Ross 1984
27 - Cole 1996f
28 - WSRC 1996c
29 - Cole 1996d

4.4.2 Excluded Radionuclides

For some sources of radionuclides in the GSA, inventories discussed in the previous section include some isotopes that are not expected to be significant contributors to potential dose in the Composite Analysis because of the extremely low quantities that are present. Radionuclides that are negligible contributors to were identified in the present analysis using trigger values (TVs) developed in a screening methodology originally applied in the E-Area PA (WSRC 1994).

The E-Area screening methodology considers the estimated concentration of each isotope in groundwater after transport from a subsurface source, such as the Burial Grounds, suspect soil trenches, or the E-Area Vaults. Radiological doses, based on ingestion of 730 L/yr (2 L/d) of groundwater at the estimated concentration of radionuclides, are then calculated using a number of conservative assumptions. Trigger values, or TVs, are calculated based on comparison to a 4 mrem/yr performance objective dose with these calculated doses. Trigger values, in units of radioactivity per disposal unit, represent the radionuclide-specific inventory at or below which doses from ingestion of groundwater are not expected to approach the PA performance objective of 4 mrem/yr. In other words, inventories of radionuclides below the TVs are insignificant with respect to radiological dose.

For the Composite Analysis, TVs for the unlined suspect soil trenches described in the E-Area PA were used. The suspect soil TVs were considered most appropriate because many of the sources in the Composite Analysis that were not addressed by PAs do not have engineered barriers. The relevant dose objective (Sect. 2.4) in the Composite Analysis is 30 mrem/yr at the points of assessment, which are at the mouths of UTR and FMB and on the Savannah River (Section 2.4.1). Thus, TVs from the E-Area PA, based on a 4 mrem/yr objective applied to groundwater 100 m from the trench, will be smaller than necessary. Furthermore, surface water concentrations that represent the point of assessment will be less than groundwater concentrations because they are calculated by diluting groundwater concentrations with baseflow occurring upstream of the region where contamination occurs. For this reason, TVs based on groundwater doses will again be smaller than necessary. Therefore, use of TVs from the E-Area PA will not lead to inappropriate exclusion of any radionuclides.

To derive TVs for suspect soil trenches, initial concentrations of radionuclides in the subsurface were calculated in the E-Area PA by assuming that a unit inventory (i.e., one Curie) of each radionuclide is placed in one unlined trench the size of the suspect soil trenches (5200 m^3). Groundwater concentrations are estimated assuming the initial concentration is diminished only by radioactive decay during the transit time period. Dilution as a result of plume dispersion is neglected. The transit time for non-sorbing radionuclides to the water table is assumed to be 5 years after release from the source (Flach 1997). Transport of sorbing radionuclides is retarded, and thus the transit time for these radionuclides can be much longer, depending on the retardation factor assumed. The estimated minimum transit time for water and nonsorbing compounds to the nearest surface water in the GSA must therefore be greater than 5 years, so the TVs are conservative with respect to transit time from the waste to the point of assessment.

In applying TVs from the E-Area PA, the total inventory of each radionuclide in GSA sources was assumed to be located in a single unlined trench, thus maximizing the radionuclide concentration considered in the screening procedure. This is conservative because the volume of these sources is greater than the capacity of the trench (5200 m^3), and the actual sources are distributed throughout the GSA and thus are more dilute initially. The total inventory of each radionuclide in the GSA, given in Table 4.4-2, was calculated by summing the inventory of each radionuclide for each source in this table. The TVs, from the E-Area PA, are also given in Table 4.4-3.

Table 4.4-3. Data for screening of radionuclides in the General Separations Area

Radionuclide	Total Inventory (Ci)	Trigger Value (Ci)	Daughter Products?	Significant Daughter(s) Not Included in Dose Factor	Estimated Activity of Significant Daughter(s)	Trigger Value(s) of Significant Daughter(s)	Exclude Radionuclide?
H-3	7.01E+06	3.30E-00	No daughters				Include
C-14	7.24E+03	8.30E-01	No daughters				Include
Na-22	1.02E-03	5.00E-02	No daughters				Exclude
K-40	2.90E-03	8.30E-03	No daughters				Include
Sc-46	3.50E-02	1.00E+05	No daughters				Exclude
Cr-51	2.40E+04	>1E20	No daughters				Exclude
Mn-54	4.49E+03	>1E20	No daughters				Exclude
Fe-55	2.88E+05	8.20E-00	No daughters				Include
Co-57	2.12E+00	>1E20	No daughters				Exclude
Co-58	6.56E+04	>1E20	No daughters				Exclude
Fe-59	2.40E+04	4.20E+11	No daughters				Exclude
Ni-59	1.05E+04	1.30E+03	No daughters				Include
Co-60	3.92E+06	1.10E+14	No daughters				Exclude
Ni-63	1.33E+06	>1E20	No daughters				Exclude
Zn-65	2.60E+00	>1E20	No daughters				Exclude
Se-79	3.24E+02	5.00E-01	No daughters				Include
Sr-90	3.73E+05	3.00E+01	Daughters	[b]			Include without daughters
Y-90	2.30E+05	>1E20	No daughters				Exclude
Mo-93	4.61E+00	1.20E-01	Daughters	Nb-93m	4.61 [d]	4.20E-01	Include with daughters
Nb-93m	2.40E+04	4.20E-01	No daughters				Include
Zr-93	2.40E+04	9.90E-02	Daughters	Nb-93m	2.04E+00 [d]	4.20E-01	Include with daughters
Nb-94	2.08E+01	3.10E-02	No daughters				Include
Nb-95	4.19E+05	3.70E+14	No daughters				Exclude
Nb-95m	4.19E+03	>1E20	Daughters	Nb-95	4.31E+02 [a]	3.70E+14	Exclude
Zr-95	1.98E+05	1.80E+07	Daughters	Nb-95	1.98E+05 [d]	3.70E+14	Exclude
Tc-99	6.51E+04	3.40E-01	No daughters				Include
Ru-103	4.14E-01	>1E20	Daughters	Rh-103m	[b]		Exclude
Rh-106	4.07E+03	>1E20	No daughters				Exclude
Ru-106	3.71E+04	>1E20	Daughters	Rh-106	[b]		Exclude
Pd-107	3.65E-02	1.10E-00	No daughters				Exclude
Ag-110m	2.42E+01	>1E20	Daughters	[b]			Exclude
In-113m	1.56E+04	>1E20	No daughters				Exclude

Table 4.4-3. continued

Radionuclide	Total Inventory (Ci)	Trigger Value (Ci)	Daughter Products?	Significant Daughter(s) Not Included in Dose Factor	Estimated Activity of Significant Daughter(s)	Trigger Value(s) of Significant Daughter(s)	Exclude Radionuclide?
Sn-113	1.56E+04	>1E20	Daughters	In-113m	1.56e4 [d]	>1E20	Exclude
Sn-119m	2.60E+05	>1E20	No daughters				Exclude
Sn-121m	2.61E+01	6.20E+14	No daughters				Exclude
Sn-123	7.55E+03	>1E20	No daughters				Exclude
Sb-125	1.46E+05	>1E20	Daughters	Te-125m	1.46E+05 [d]	1.40E+08	Exclude
Te-125m	8.48E+04	1.40E+08	No daughters				Exclude
Sb-126	1.30E+01	>1E20	No daughters				Exclude
Sb-126m	2.73E-01	>1E20	Daughters	Sb-126	2.91E-04 [a]	>1E20	Exclude
Sn-126	1.35E+02	6.20E-00	Daughters	[b]			Include without daughters
Te-127	1.56E-01	>1E20	No daughters				Exclude
Te-127m	1.61E-01	2.20E+03	Daughters	[b]			Exclude
I-129	2.25E+01	2.30E-03	No daughters				Include
Cs-134	1.80E+04	>1E20	No daughters				Exclude
Cs-135	6.82E-02	1.1	No daughters				Exclude
Ba-137m	2.92E+04	>1E20	No daughters				Exclude
Cs-137	2.77E+05	>1E20	Daughters	[b]			Exclude
Ce-144	1.95E+04	>1E20	Daughters	[b]			Exclude
Pr-144	1.95E+04	>1E20	No daughters				Exclude
Pr-144m	2.25E+02	>1E20	Daughters	Pr-144	9.38E+01 [a]	>1E20	Exclude
Pm-147	9.61E+04	>1E20	Daughters	Sm-147	3.65E-05 [a]	4.40E-01	Exclude
Sm-151	*4.87E+03*	*5.60E+10*	*No daughters*				*Exclude*
Eu-152	1.25E+01	>1E20	Daughters	Gd-152	1.55E-12 [a]	5.30E-01	Exclude
Eu-154	1.35E+04	>1E20	No daughters				Exclude
Eu-155	1.52E+03	>1E20	No daughters				Exclude
Hf-181	2.40E+04	>1E20	No daughters				Exclude
Ta-182	5.66E+04	>1E20	No daughters				Exclude
Pb-212	9.35E-03	>1E20	Daughters	[b]			Exclude
Ra-226	1.64E-01	7.50E+01	Daughters	Pb-210	1.64E-01 [d]	>1E20	Include with daughters
				Po-210	1.64E-01 [d]	9.3E-02	
Ac-228	2.40E-03	>1E20	Daughters	Th-228	8.78E-07 [a]	>1E20	Exclude
Th-228	3.30E-03	>1E20	Daughters	[b]			Exclude

Table 4.4-3. continued

Radionuclide	Total Inventory (Ci)	Trigger Value (Ci)	Daughter Products?	Significant Daughter(s) Not Included in Dose Factor	Estimated Activity of Significant Daughter(s)	Trigger Value(s) of Significant Daughter(s)	Exclude Radionuclide?
Th-230	1.20E-03	8.80E-00	Daughters	Ra-226	4.20E-04 [c]	7.5E+00	Exclude
				Po-210	4.20E-04 [c]	9.3E-02	
Th-231	1.30E-01	>1E20	Daughters	Pa-231	2.28E-07 [a]	7.4E-05	Exclude
				Ac-227	2.28e-07 [d]	>1E20	
Th-232	7.70E+00	8.50E-01	Daughters	Ra-228	7.70E+00 [d]	>1E20	Include without daughters
U-232	2.20E-01	5.40E+03	Daughters	Th-228	2.20E-01 [d]	>1E20	Exclude
U-233	2.40E+00	1.50E-01	Daughters	Th-229	2.16E-01 [c]	7.40E+02	Include without daughters
Pa-234	3.90E-03	>1E20	Daughters	U-234	1.22E-11 [a]	1.50E-01	Exclude
Th-234	2.00E-03	>1E20	Daughters	U-234	5.40E-10 [a],	1.5E-02	Exclude
				Th-230	4.82E-12 [c],	8.8E01	
				Ra-226	9.10E-13 [c]	7.5E+00	
U-234	7.88E+01	1.50E-01	Daughters	Th-230	7.05E-01 [c]	8.8E-01	Include with daughters
				Ra-226	1.33E-01 [c]	7.5E+00	
				Po-210	1.25E-01 [c]	9.3E-02	
U-235	2.45E+00	1.60E-01	Daughters	Pa-231	5.13E-02 [c]	7.40E-04	Include with daughters
Pu-236	1.11E-01	>1E20	Daughters	U-232	4.40E-03 [a]	5.4E+02	Exclude
				Th-228	4.40E-03 [d]	>1E20	
U-236	8.82E+00	1.60E-01	Daughters	Th-232	2.14E-03 [a]	8.50E-01	Include without daughters
Np-237	1.43E+01	2.10E-03	Daughters	U-233	6.21E-02 [c]	1.50E-01	Include with daughters
Pu-238	3.64E+04	8.20E+06	Daughters	U-234	1.31E+01 [a]	1.50E-01	Include with daughters
U-238	6.36E+01	1.70E-01	Daughters	U-234	1.80E-01 [c]	1.50E-01	Include with daughters
Np-239	3.16E+03	>1E20	Daughters	Pu-239	8.45E-04 [a]	2.00E-02	Exclude
Pu-239	2.02E+03	2.00E-02	Daughters	U-235	6.93E-02 [a]	1.60E-01	Include with daughters
Pu-240	4.35E+02	2.40E-02	Daughters	U-236	8.33e-01 [a]	1.60E-01	Include with daughters
Am-241	2.33E+03	1.10E+01	Daughters	Np-237	4.70E-01 [a]	2.10E-03	Include with daughters
Pu-241	1.86E+04	>1E20	Daughters	Am-241	6.20E+02 [a]	1.10E+01	Include with daughters
Am-242	9.07E-02	>1E20	Daughters	Pu-242	4.41E-10 [a]	1.90E-02	Exclude
Am-242m	4.38E-01	7.70E+05	Daughters	Pu-238	7.35E-02 [c]	8.20E+06	Exclude
Cm-242	1.68E+01	>1E20	Daughters	Pu-238	5.10E-03 [a]	8.20E+05	Exclude
				U-234	1.83E-06 [a]	1.50E-02	
Pu-242	1.08E-01	1.90E-02	Daughters	U-238	9.08E-06 [a]	1.70E-01	Include without daughters

Table 4.4-3. continued

Radionuclide	Total Inventory (Ci)	Trigger Value (Ci)	Daughter Products?	Significant Daughter(s) Not Included in Dose Factor	Estimated Activity of Significant Daughter(s)	Trigger Value(s) of Significant Daughter(s)	Exclude Radionuclide?
Am-243	1.99E+00	3.70E-02	Daughters	Pu-239	3.06E-01 [a]	2.00E-02	Include with daughters
Cm-243	2.60E-02	>1E20	Daughters	Pu-239	3.07E-05 [a]	2.00E-02	Exclude
Cm-244	4.79E+04	>1E20	Daughters	Pu-240	1.33E+02 [a]	2.40E-03	Include with daughters
				U-236	9.17E+01[a]	1.60E-02	
Pu-244	8.88E-11	2.00E-02	Daughters	Pu-240	9.82E-15 [c]	2.40E-02	Exclude
Cm-245	1.73E-02	2.20E-02	Daughters	Pu-241	1.73E-02 [d]	>1E20	Exclude
				Am-241	1.73E-02 [d]	1.1E+00	
				Np-237	3.49E-06 [a]	2.1E-04	
Cm-246	2.69E-02	2.50E-02	Daughters	Pu-242	3.40E-04 [a]	1.90E-02	Include without daughters
Cm-247	1.27E-07	1.90E-02	Daughters	Am-243	1.27E-07 [d]	3.7E-03	Exclude
				Pu-239	1.27E-07 [d]	2.0E-03	
Cm-248	5.97E-11	5.00E-03	Daughters	Pu-244	2.45e-13 [a]	2.00E-02	Exclude
Cf-249	3.98E-10	2.40E-00	Daughters	Cm-245	1.64e-11 [a]	2.20e-3	Exclude
				Pu-241	1.64e-11[d]	>1E20	
Cf-251	2.41E-09	1.20E-01	Daughters	Cm-247	1.39E-13 [a]	1.90E-03	Exclude
				Am-243	1.39E-13 [d]	3.70E-03	
Cf-252	5.93E+01	>1E20	Daughters	Cm-248	4.62E-04 [a]	5.00E-03	Exclude

Note: a - Radioactive daughter much longer-lived than parent; activity of daughter calculated assuming parent decays instantaneously to daughter a time t = 0.

Note: b - Radioactive daughter(s) not potentially significant (because of short half life) except as accounted for in dose conversion factor.

Note: c - Half life of radioactive daughter somewhat shorter than that of parent; daughter assumed to be in secular equilibrium with parent at all times, and initial activity of daughter assumed to be the amount that would grow in by 1000 years if the parent were not leached from the facility.

Note: d - Half life of parent much longer than that of daughter; activity of daughter(s) assumed to equal that of parent at all times.

For radionuclides that do not produce radioactive daughter products, a simple comparison between the summed inventory and the TV for that radionuclide determines if the radionuclide can be excluded from the Composite Analysis. Those with inventories less than the TV can be assumed to be negligible potential contributors to dose. In Table 4.4-3, radionuclides that do not produce daughters are indicated, and a subset of those radionuclides is indicated as "excluded" from further analysis based on the comparison of their total inventory with the TVs. Radionuclides that do not produce radioactive daughters, and were not excluded from further analysis are: ^{14}C, ^{55}Fe, ^{3}H, ^{129}I, ^{40}K, ^{93m}Nb, ^{94}Nb, ^{59}Ni, ^{79}Se, and ^{99}Tc.

Radionuclides that produce radioactive daughters are also identified in Table 4.4-3. Potential inventories of radioactive daughters must be considered in addition to the inventory of the parent radionuclide for these radionuclides. For radionuclides with shorter-lived daughter products with half-lives on the order of a few days or less, contributions of daughter products to dose are addressed in the dose conversion factors for the parent. Consideration of these short-lived daughters separately is unwarranted because these daughters are always intimately associated with the parent. Radionuclides with daughters that fall into this category are ^{110m}Ag, ^{144}Ce, ^{137}Cs, ^{212}Pb, ^{103}Ru, ^{106}Ru, ^{126}Sn, ^{90}Sr, ^{127m}Te, and ^{228}Th. Screening of these radionuclides was done on the basis of the parent inventory alone. All of these radionuclides, with the exception of ^{126}Sn and ^{90}Sr, are fairly short-lived and were excluded from further consideration in the Composite Analysis.

Some radionuclides in Table 4.4-3 are shorter-lived than one or more radioactive daughter products. Therefore, a radioactive daughter could conceivably be more radiologically significant than its parent, and this possibility was considered in the screening analysis. For radionuclides with half-lives shorter than one or more daughters, the activity of the daughters was conservatively assumed to be the activity that would result if the parent decayed instantaneously to the longer-lived daughter when placed in the trench. The initial activity of the daughter was calculated from:

$$A_D = A_P \frac{T_{1/2\ P}}{T_{1/2\ D}},$$

where

A_D	=	initial activity of the daughter, Ci,
A_P	=	initial activity of the parent, Ci,
$T_{1/2\ D}$	=	half-life of the daughter (yr), and
$T_{1/2\ P}$	=	half-life of the parent (yr).

In some cases, this was an excessively conservative assumption, because the half-life of the parent was often significant. For example, this equation was used to estimate the activity of the ^{239}Pu daughter of ^{243}Am. Even if ^{243}Am and ^{239}Pu were immobile and remained in the trench for 1000 years, the activity of ^{239}Pu would only approach about 3 percent of the activity of ^{243}Am. However, for screening purposes, conservatism is desirable. The daughter activities calculated using the above equation were compared with the appropriate TVs to determine if the daughters might make significant contributions to dose. Radionuclides with potentially significant daughter contributions identified by this method are: ^{241}Am, ^{243}Am, ^{244}Cm, ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Pu.

Radioactive daughter products that are much shorter-lived than the parent radionuclide, but not sufficiently short-lived that the contribution to dose is fully accounted for in the dose factor are assumed to be in equilibrium with the parent radionuclide, and thus have the same activity as the parent. This assumption was made for:

- the ^{241}Pu and ^{241}Am daughters of ^{245}Cm,
- the ^{243}Am and ^{239}Pu daughters of Cm-247,
- the ^{210}Pb and ^{210}Po daughters of ^{226}Ra,
- the ^{125m}Te daughter of ^{125}Sb,
- the ^{228}Ra daughter of ^{232}Th,
- the ^{228}Th daughter of ^{232}U (in both the ^{236}Pu and ^{232}U decay chains),
- the ^{93m}Nb daughter of ^{93}Mo and ^{93}Zr, and
- the ^{95}Nb daughter of ^{95}Zr.

The only identified parent radionuclides listed in Table 4.4-3 with potentially significant daughters in equilibrium (that are not sufficiently accounted for in the dose factor) are ^{93}Mo and ^{93}Zr.

Finally, some radioactive daughter products are characterized by half-lives only somewhat less than that of the parent, such that a state of secular equilibrium is approached over time. When secular equilibrium is achieved, a constant ratio is established between the activity of the parent and the daughter, which is not equal to unity. Depending on the half-lives of the parent and daughter radionuclides, secular equilibrium may not occur within 1000 years, the maximum time of assessment; therefore, the activity ratio that would occur at 1000 years, neglecting leaching, was assumed for the initial ratio of parent:daughter activities in the Composite Analysis screening. This method greatly over predicts the activity of the daughter(s), but is appropriate for this screening exercise. Radioactive daughter products assumed to be in secular equilibrium with the parent radionuclide are:

- the ^{238}Pu daughter of ^{242m}Am,
- the ^{233}U daughter of ^{237}Np,
- the ^{227}Ac daughter of ^{231}Pa (in the ^{231}Th decay chain),
- the ^{236}U daughter of ^{240}Pu (in both the ^{240}Pu and ^{244}Pu decay chains),
- the ^{210}Po daughter of ^{230}Th,
- the ^{230}Th, ^{226}Ra, and ^{210}Po daughters of ^{234}U (in both the ^{234}Th and ^{234}U decay chains),
- the ^{231}Pa daughter of ^{235}U, and
- the ^{234}U daughter of ^{238}U.

Parent radionuclides, with one or more daughters assumed to be in secular equilibrium and that were identified as potentially significant contributors to dose are: ^{237}Np, ^{226}Ra, ^{234}U, ^{235}U, and ^{238}U.

Despite consideration of daughter products, some parent radionuclides were considered potentially significant based on the activity of the parent alone; consideration of the daughter products did not indicate daughters would be potentially important contributors to dose for these radionuclides. These radionuclides are: ^{246}Cm, ^{242}Pu, ^{232}Th, ^{233}U, and ^{236}U.

Based on the screening procedure described above, 31 radionuclides were identified for which a more detailed analysis of potential contribution to dose must be carried out. These radionuclides are: ^{241}Am, ^{243}Am, ^{14}C, ^{244}Cm, ^{246}Cm, ^{55}Fe, ^{3}H, ^{129}I, ^{40}K, ^{93}Mo, ^{93m}Nb, ^{94}Nb, ^{59}Ni, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{226}Ra, ^{79}Se, ^{126}Sn, ^{90}Sr, ^{99}Tc, ^{232}Th, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U, and ^{93}Zr.

4.4.3 Source Term Estimates

In this report, the definition of source term is the amount of each radionuclide released to the environment per year. As shown in Section 4.3, the only pathways of concern for the Composite Analysis are those associated with initial groundwater transport of contamination.

The PATHRAE computer program (See Appendix D) was used to calculate the annual flux of radionuclides to the water table. Five input files are required for PATHRAE; however, only three of them have information which is specific to a facility and the groundwater pathway, ABCDEF.DAT, INVNTRY.DAT, and RQSITE.DAT. ABCDEF.DAT contains facility dimensions and hydrologic properties. INVNTRY.DAT is the facility radionuclide inventory data, and RQSITE.DAT has the partition coefficient (K_d) and leach rate information.

The areal dimensions for each facility were measured from maps in the SRS Site Atlas (WSRC, 1995b). Depth to the water table was determined from an intranet page on the SRS network supported by the Environmental Geochemistry Group (WSRC 1997b). Hydrologic parameters were taken from the EAV PA (WSRC 1994). Facility inventories and radionuclide screening have been described in Sections 4.4.1 and 4.4.2, respectively. Partition coefficient values for geologic materials were also taken from the EAV PA.

With one exception, leach rates, as a function of waste zone K_d, were calculated within PATHRAE. The leach rate for ^{14}C from ion exchange resin was taken a modeling study on this particular waste form (Cook 1989) based on data from lysimeters (McIntyre 1987). Waste zone K_d values were taken from the EAV PA for those facilities where radionuclides are in direct contact only with the soil column, and from a recent reference (Bradbury and Sarott 1995) for those facilities where concrete or cement-based materials were involved. Table 4.4-4 provides K_d values and the source of those values used in the Composite Analysis. The PATHRAE analyses simulated releases over a period of 11,000 years.

For source term modeling, the facilities can be divided into several groups. These are PA derived, existing waste sites, tanks, buildings and spills. The treatment of each of these groups is discussed below.

PA Derived Source Terms

Those new disposal facilities which have been modeled as part of a Performance Assessment, Saltstone vaults, LAW vaults, ILT vaults, Naval Reactor Components and E-Area Trenches used the results of the PA model for flux of radionuclides to the water table.

Existing Waste Sites

Existing solid waste sites were modeled for their actual time of operation. These were 1954 to 1972 for the OBG and 1972 to 1994 for the MWMF. Lysimeters were treated as separate sources within the MWMF. The MWMF and OBG were modeled without a closure cap. The F- and H-Area Seepage Basins were modeled as closed systems, including a closure cap, beginning in 1988.

Table 4.4-4 Sorption coefficients (K_ds) and half-lives of radionuclides for which transport is simulated in the composite analysis of the GSA

Radionuclide	Cement K_d (ml/g)[a]	Soil K_d (ml/g)[b]	Clay K_d (ml/g)[b]
Ac	5000	450	2400
Am	5000	1900[d]	8400[d]
Bi	---[c]	100	600
C	7000	2[e]	1
Cf	5000	1900[d]	8400[d]
Cm	5000	1900[d]	6000[d]
Fe	100	220	165
H	0	0	0
I	2	0.6[f]	1
K	0.1	15	75
Mo	0.1	10	90
Nb	500	160	900
Ni	500	400	650
Np	5000	5	55
Pa	5000	550	2700
Pb	500	270	550
Po	500	150	3000
Pu	5000	100[f]	5100
Ra	50	500	9100
Se	10	5[g]	740
Sn	1000	130	670
Sr	10	10[f]	110
Ta	---[c]	220	1200
Tc	1	0.36[h]	1
Th	5000	3000	5800
U	1900	35	1600
Zr	5000	600	3300

[a] Bradbury and Sarott, 1995; [b] Sheppard and Thibault, 1990; [c] Case does not occur;

[d] Baes and Sharp, 1983; [e] McIntyre, 1988; [f] Hoeffner, 1985; [g] Ticknor and Ruegger, 1989;

[h] Oblath, 1982

Tanks

Both high level waste tanks and solvent tanks were represented as concrete monoliths, based on the approved closure plans submitted to the State of South Carolina. Each HLW tank was modeled as containing the expected residual radionuclide inventory after waste removal and closure. Key assumptions were that the tanks remain intact for 300 years and that infiltration was reduced by the concrete.

Buildings

Process buildings, F- and H-Area Canyons, the DWPF, the Sand Filters and the 772-F laboratories, were modeled as a concrete slab, with the footprint of the existing structure, contaminated with the assumed inventory. No cap was assumed for these facilities.

Spills

The only spills of sufficient magnitude (total activity > 1 curie) to be considered in the CA were associated with the high level waste tanks (D'Entremont, 1988). The spill inventory was added to the residual inventory of the tank group within which the spill was located.

Contaminated Fourmile Branch Sediments

Fourmile Branch has received effluent from the F- and H-Area Seepage Basins and the Old Burial Ground (Carlton et al. 1992). However, the quantities of radioactive material in transport in FMB are very low. In 1994, a total of 3 millicuries of ^{137}Cs was in transport in FMB just downstream of the GSA (WSRC 1996c). If a person were to be exposed directly to this amount of ^{137}Cs, the resulting dose from all pathways, including drinking 730 liter of water per year, would be only 0.4 mrem/year. Thus, this source of radioactive material is not significant and is not considered further.

The individual facility-specific parameters used in the PATHRAE runs can be found in Appendix B.

PATHRAE output consisted of curies per year of each radionuclide transported to the water table. These results are presented in Figures 4.4.1 through 4.4.15.

4.4.4 Excluded Source Terms

The source terms derived for the composite analysis, describing radionuclide release to the water table, varied greatly in magnitude, from less than 10^{-18} to greater than 10^{4} Ci/yr. A methodology was developed to screen the source terms with respect to potential impact, thereby focusing the subsequent analyses only on sources of potential significance. The methodology implemented is described in this section.

The source term criterion developed as part of the screening methodology is based on an all-pathways dose analysis. The criterion defines a magnitude of release to the water table, below which associated impacts of the source term are expected to be considerably less than 1 mrem/yr. In order to develop this criterion, it was assumed that releases to the water table were not diminished by sorption or radioactive decay during transport in the subsurface, such that a release to the water table eventually became a discharge to a stream. Thus, a 1 Ci/yr release to the water table was considered a 1 Ci/yr release to a stream.

In order to base the release criterion on potential impact, a dose to a hypothetical maximally-exposed individual was calculated for a unit release (1 Ci/yr) to the water table of each radionuclide listed in Table 4.4-3. The list of radionuclides is taken from

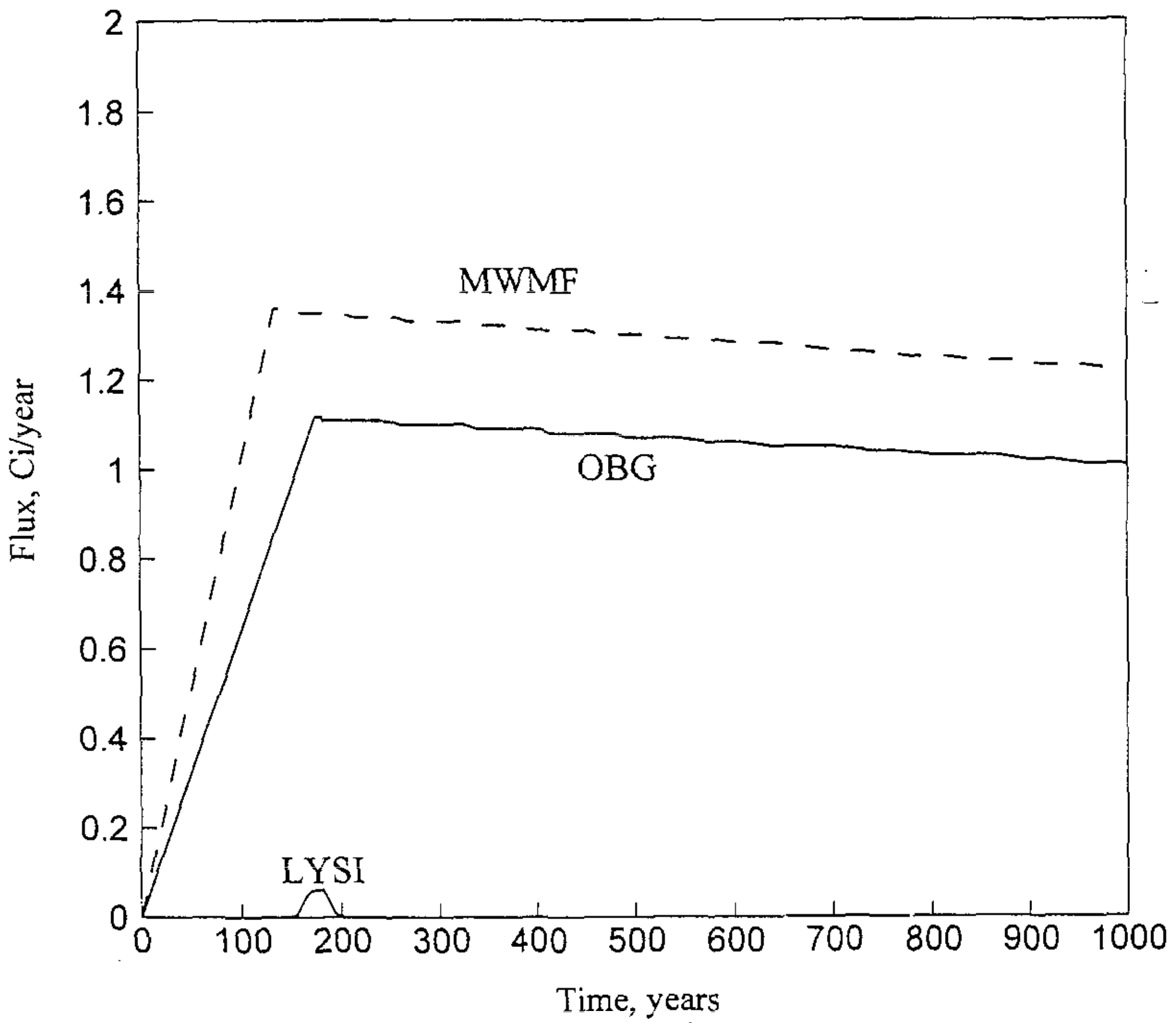

Figure 4.4-1. ^{14}C ***flux to the water table***

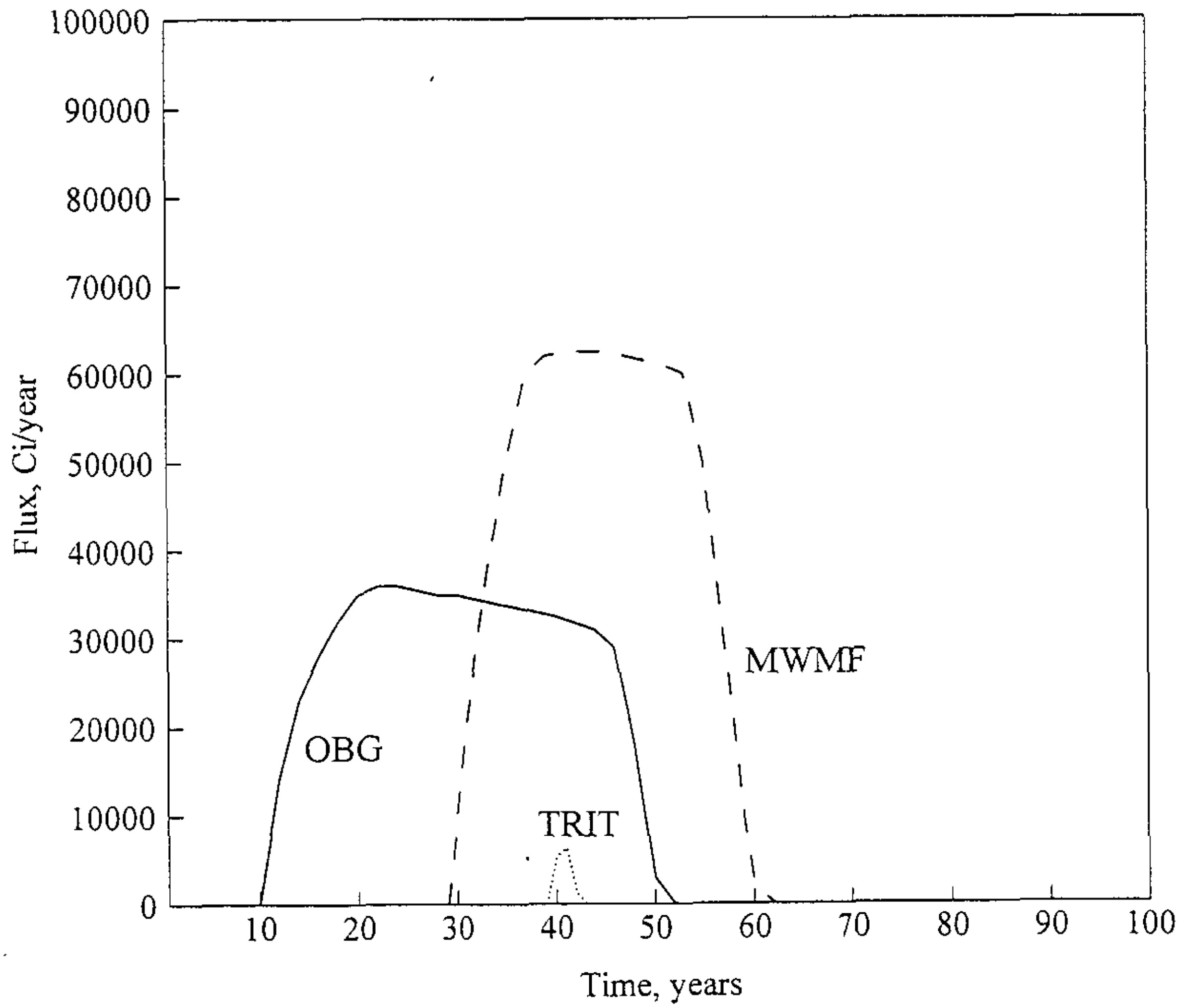

Figure 4.4-2. ^{3}H flux to the water table

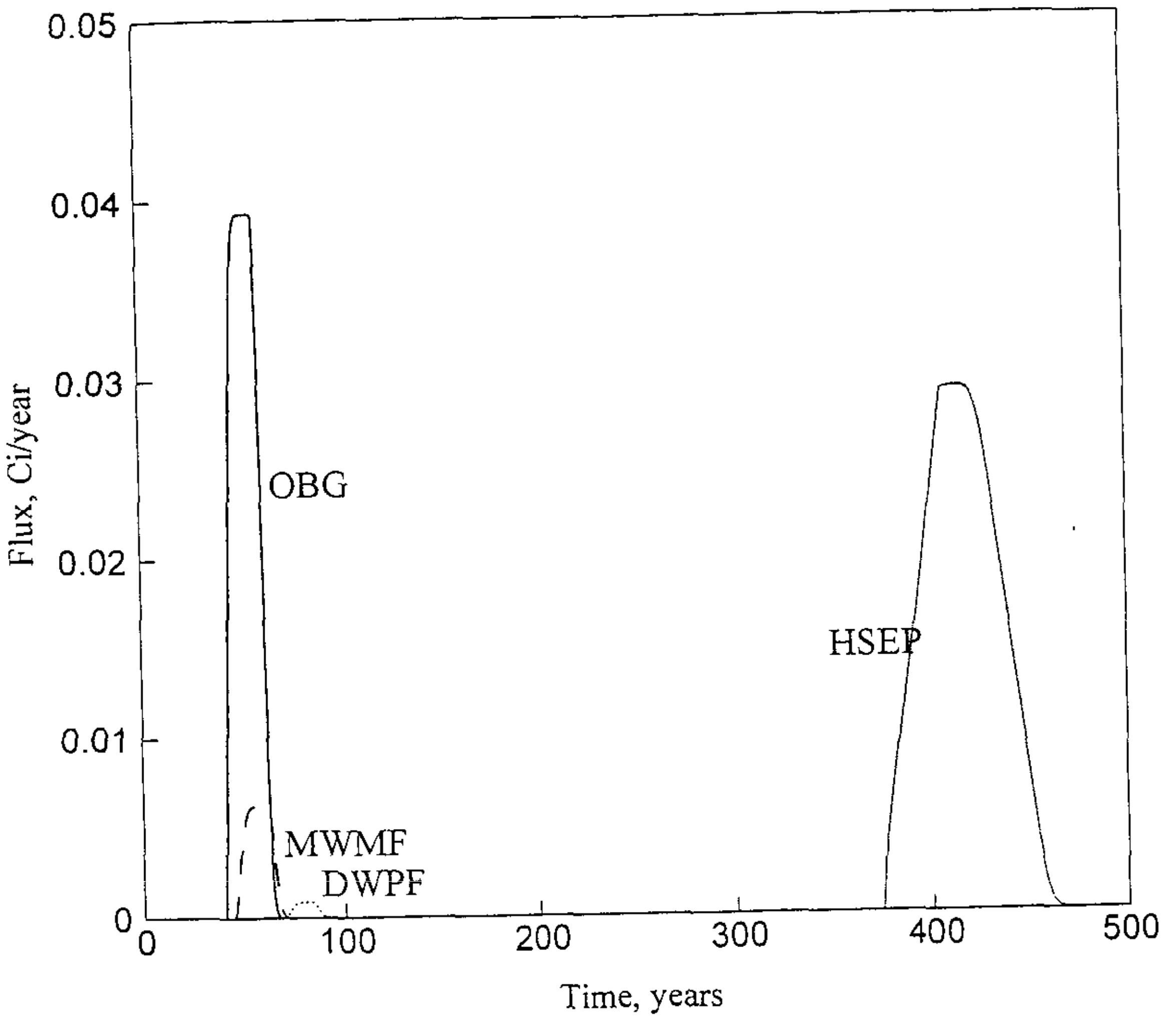

Figure 4.4-3. **^{129}I flux to the water table**

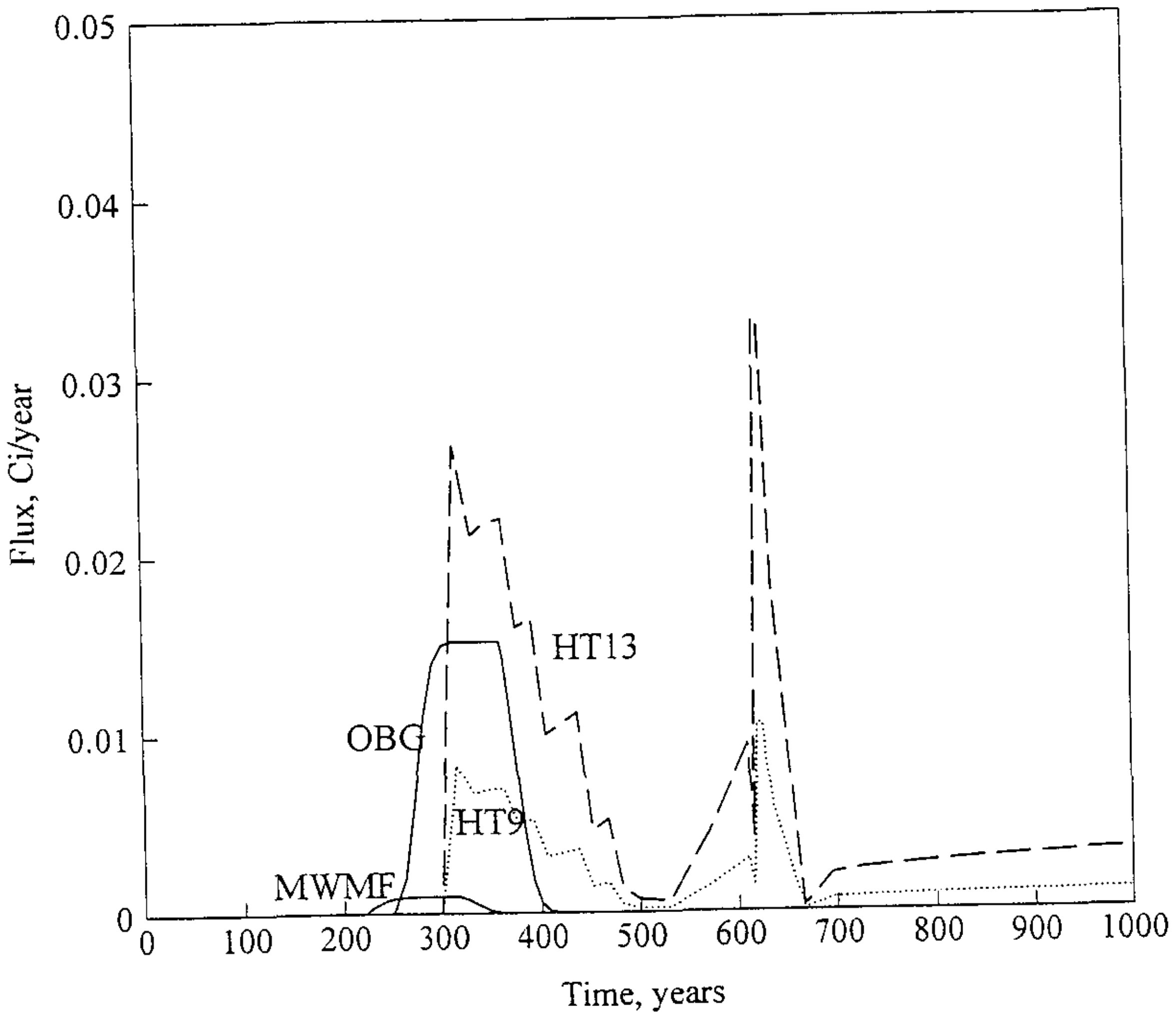

Figure 4.4-4. ^{237}Np **flux to the water table**

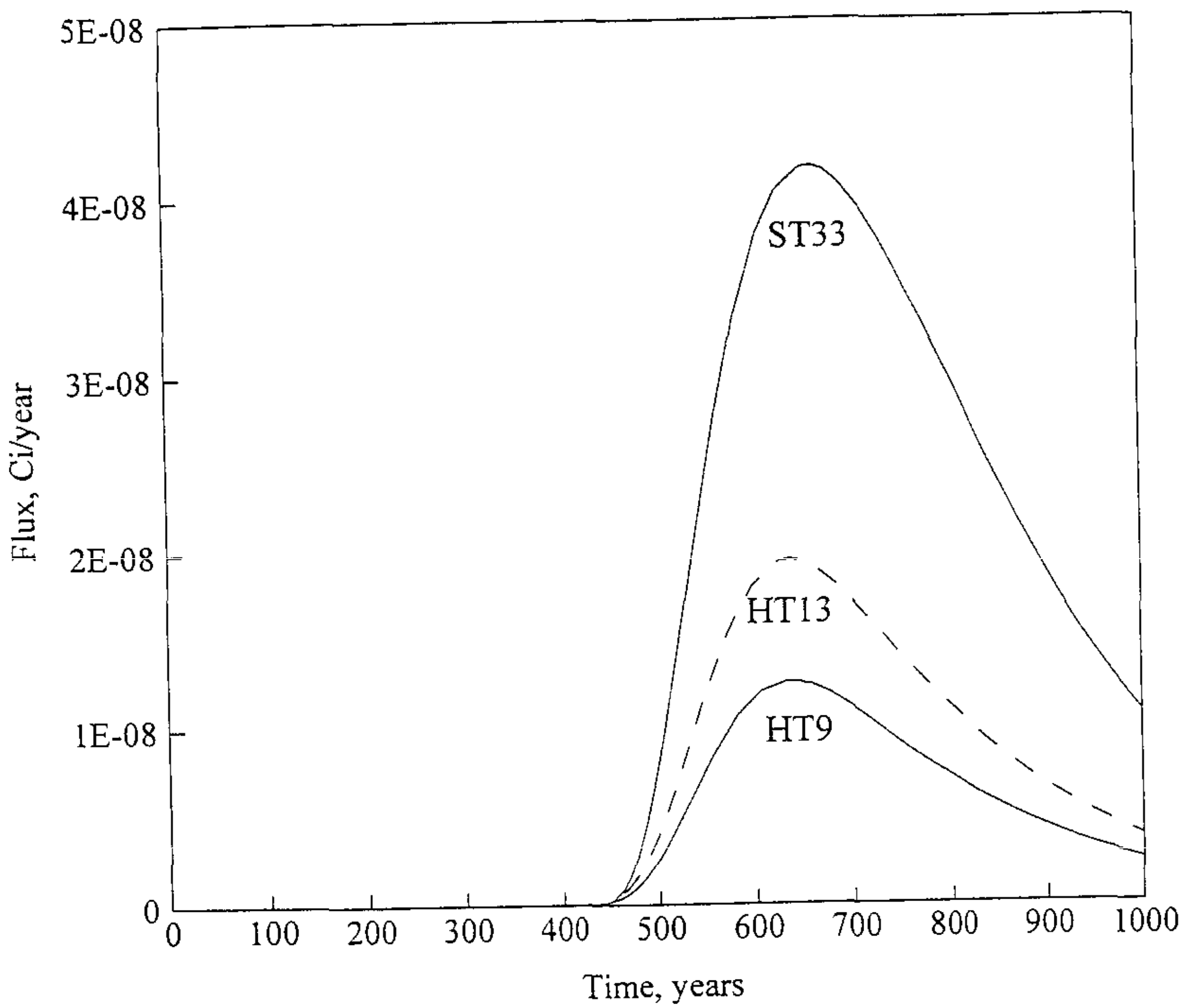

Figure 4.4-5. ^{238}**Pu flux to the water table**

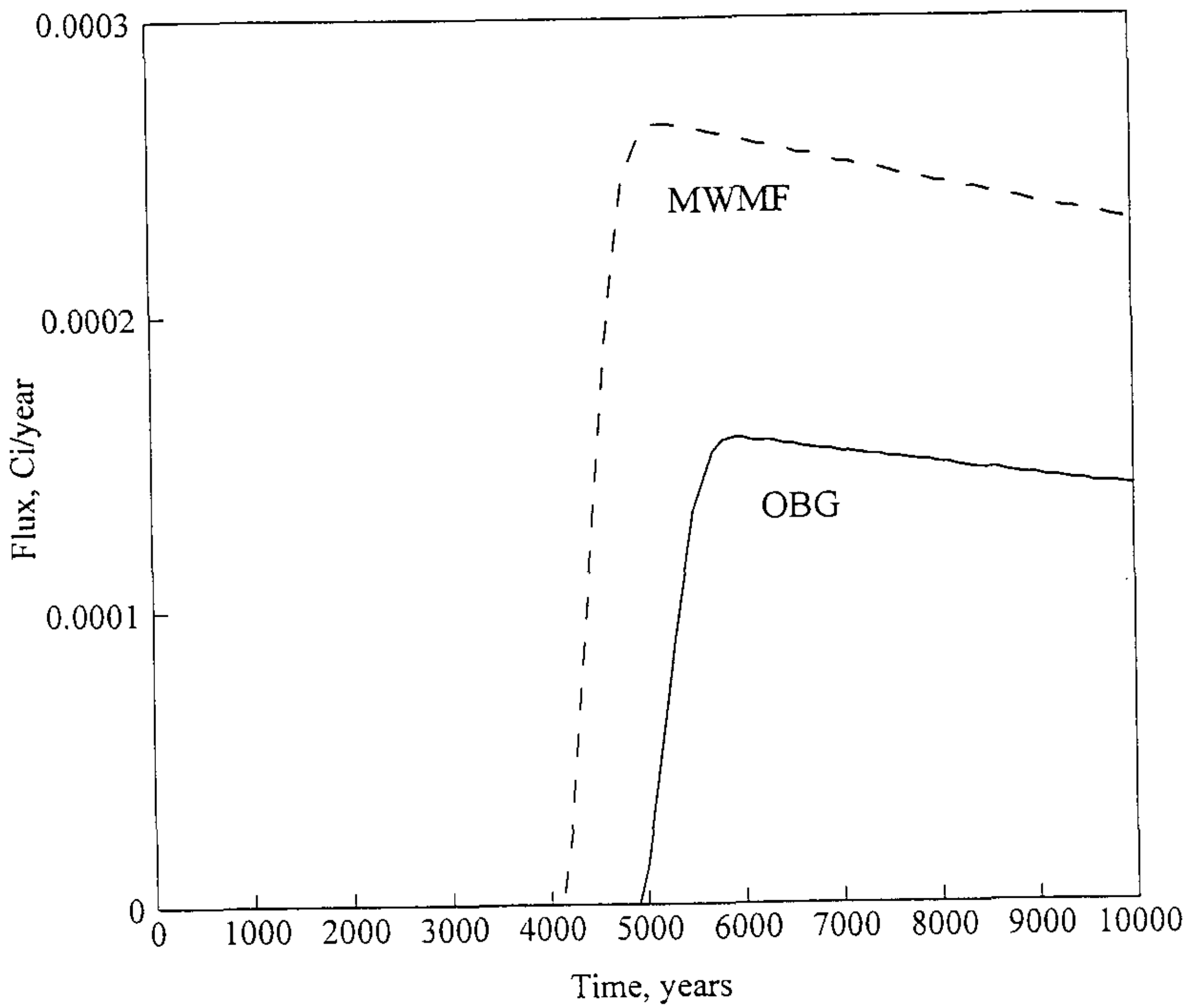

Figure 4.4-6. ^{239}**Pu flux to the water table**

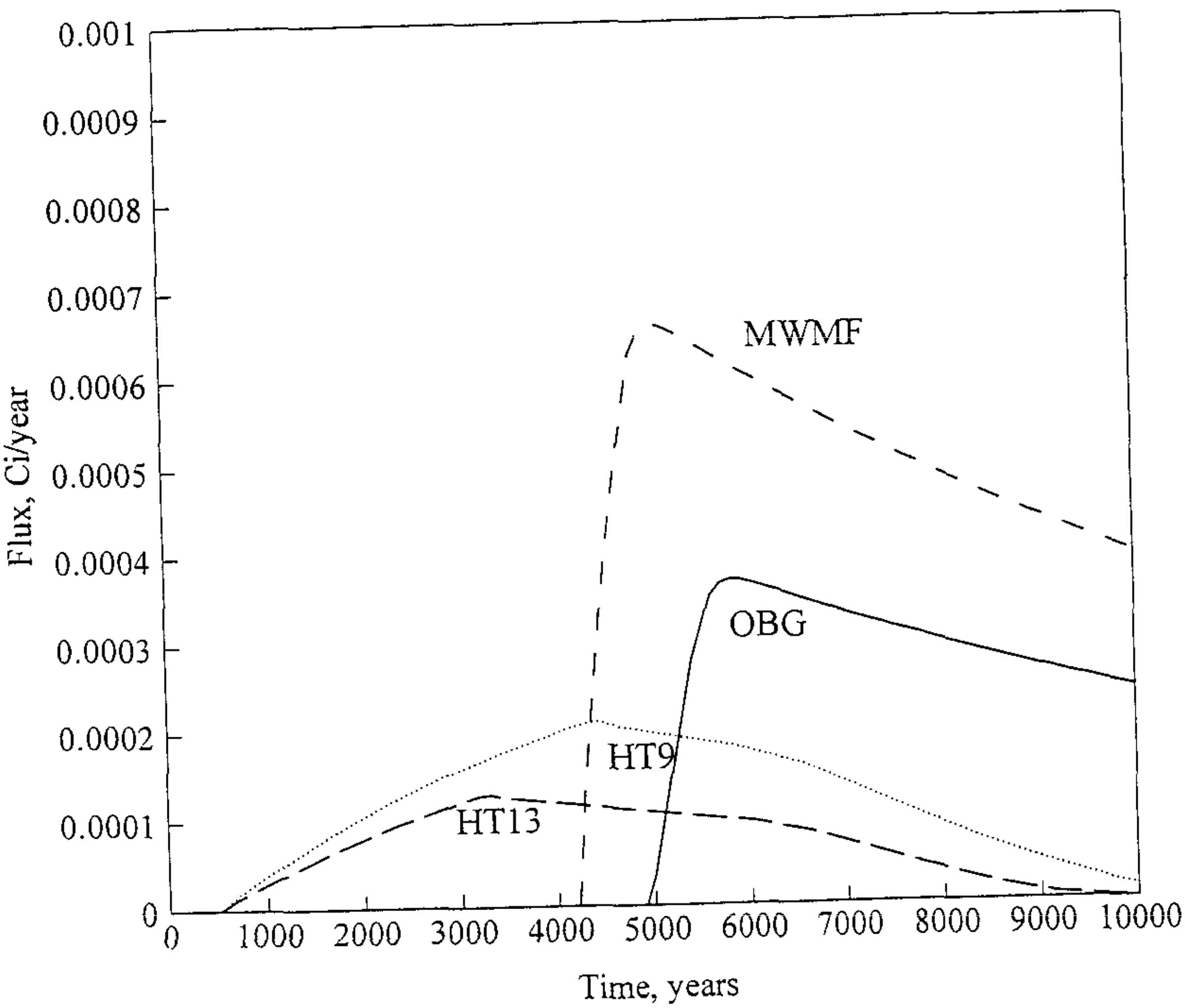

Figure 4.4-7. ^{240}Pu flux to the water table

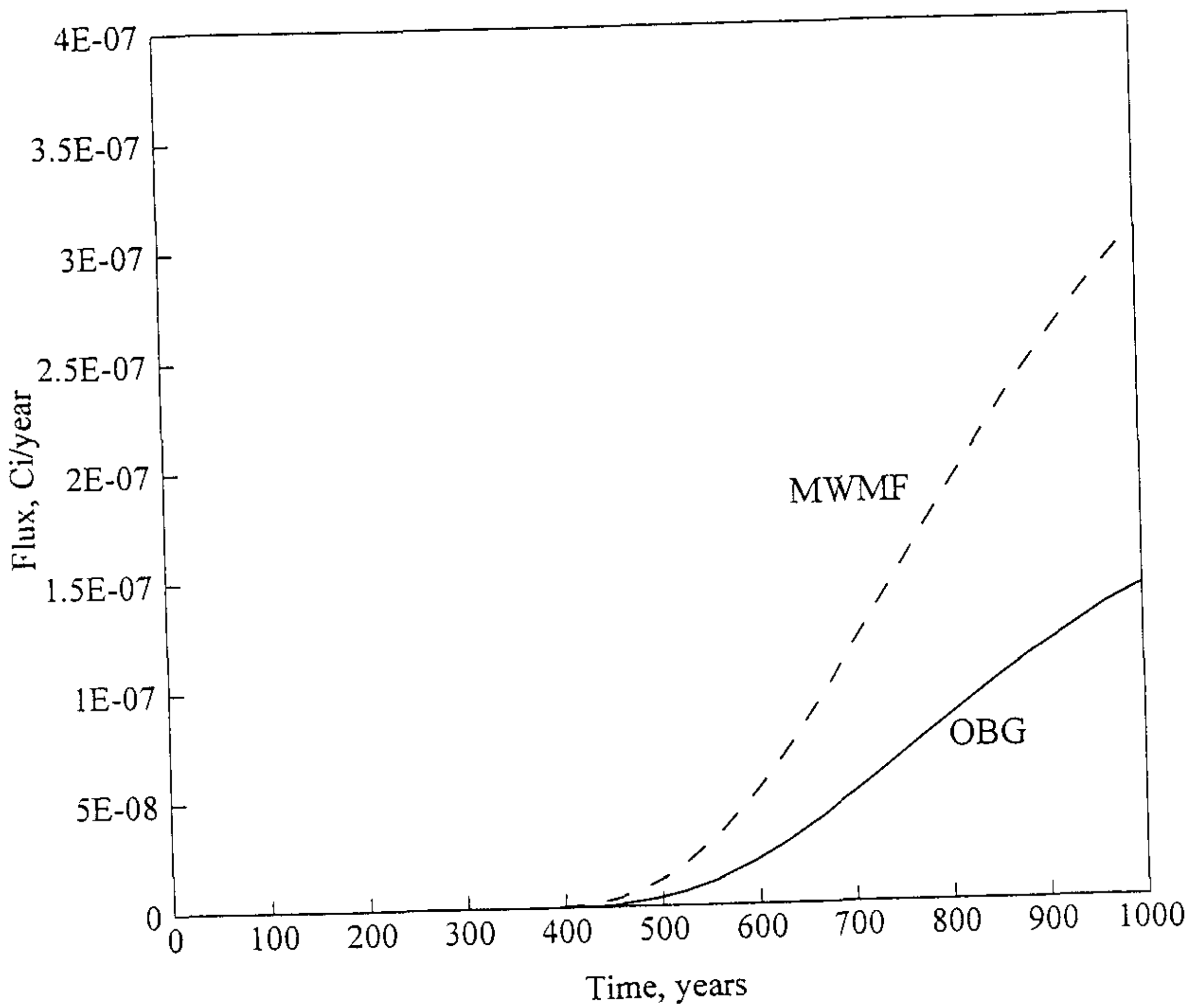

Figure 4.4-8. ^{226}Ra flux to the water table

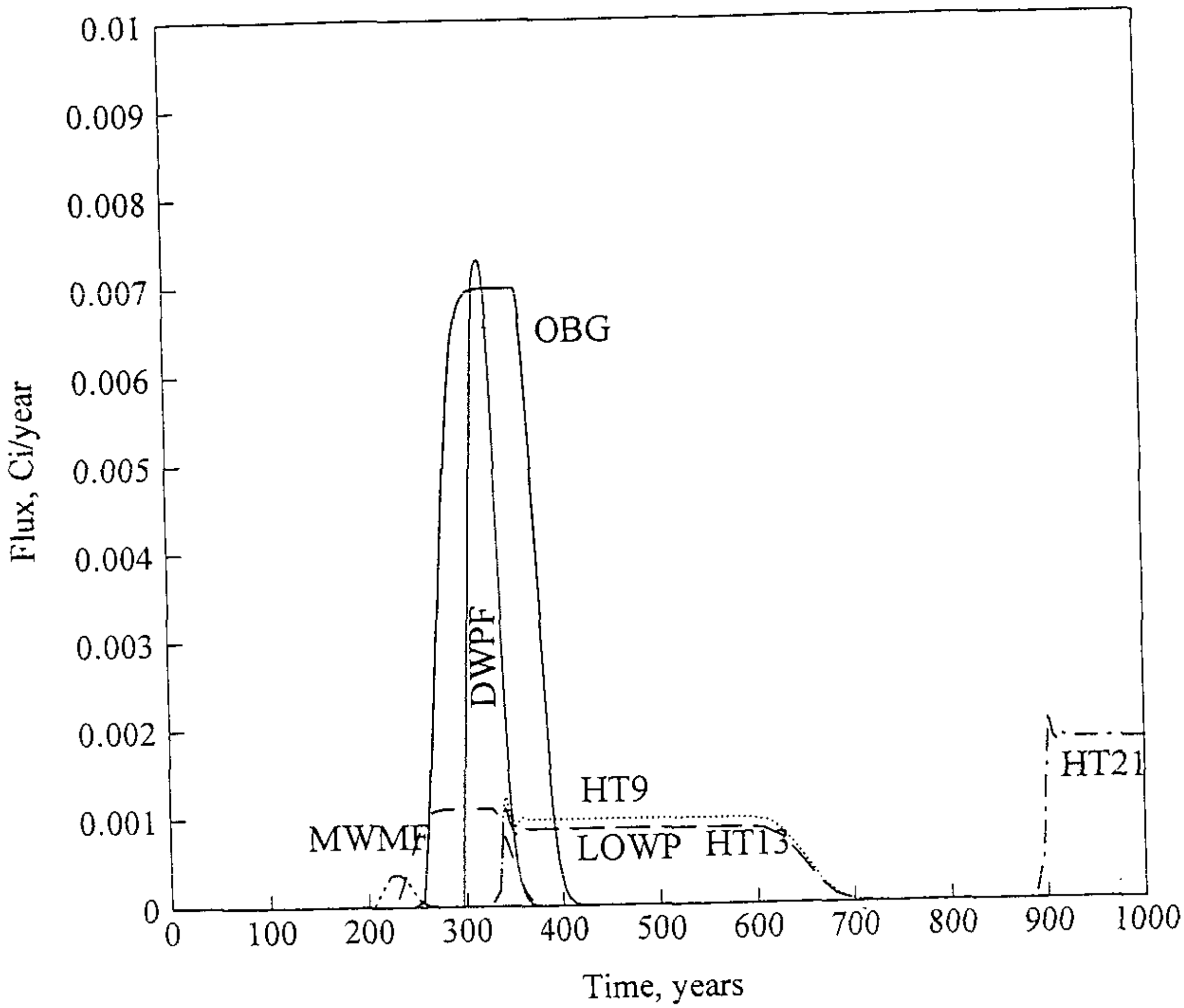

Figure 4.4-9. ^{79}**Se flux to the water table**

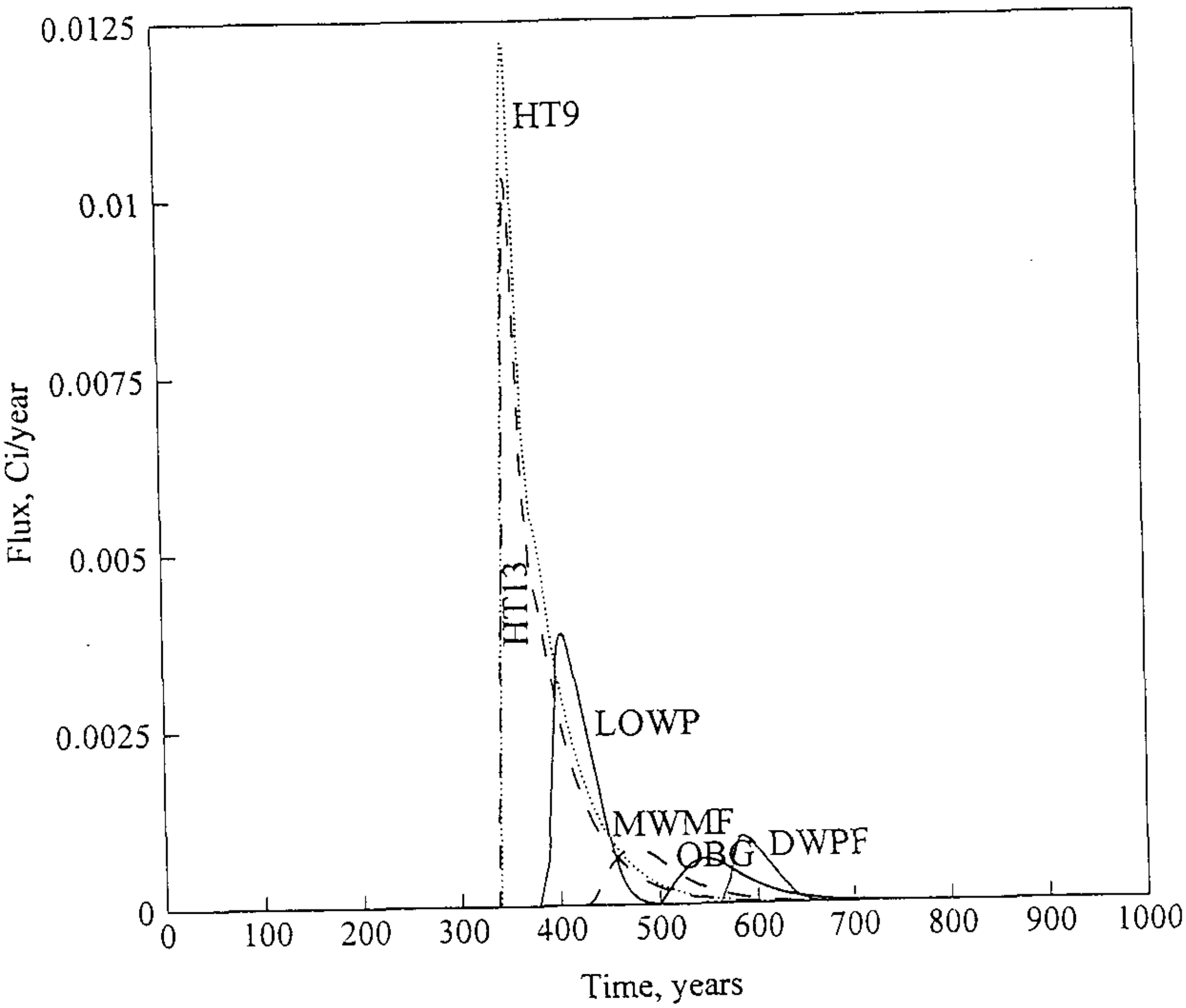

Figure 4.4-10. ^{90}**Sr flux to the water table**

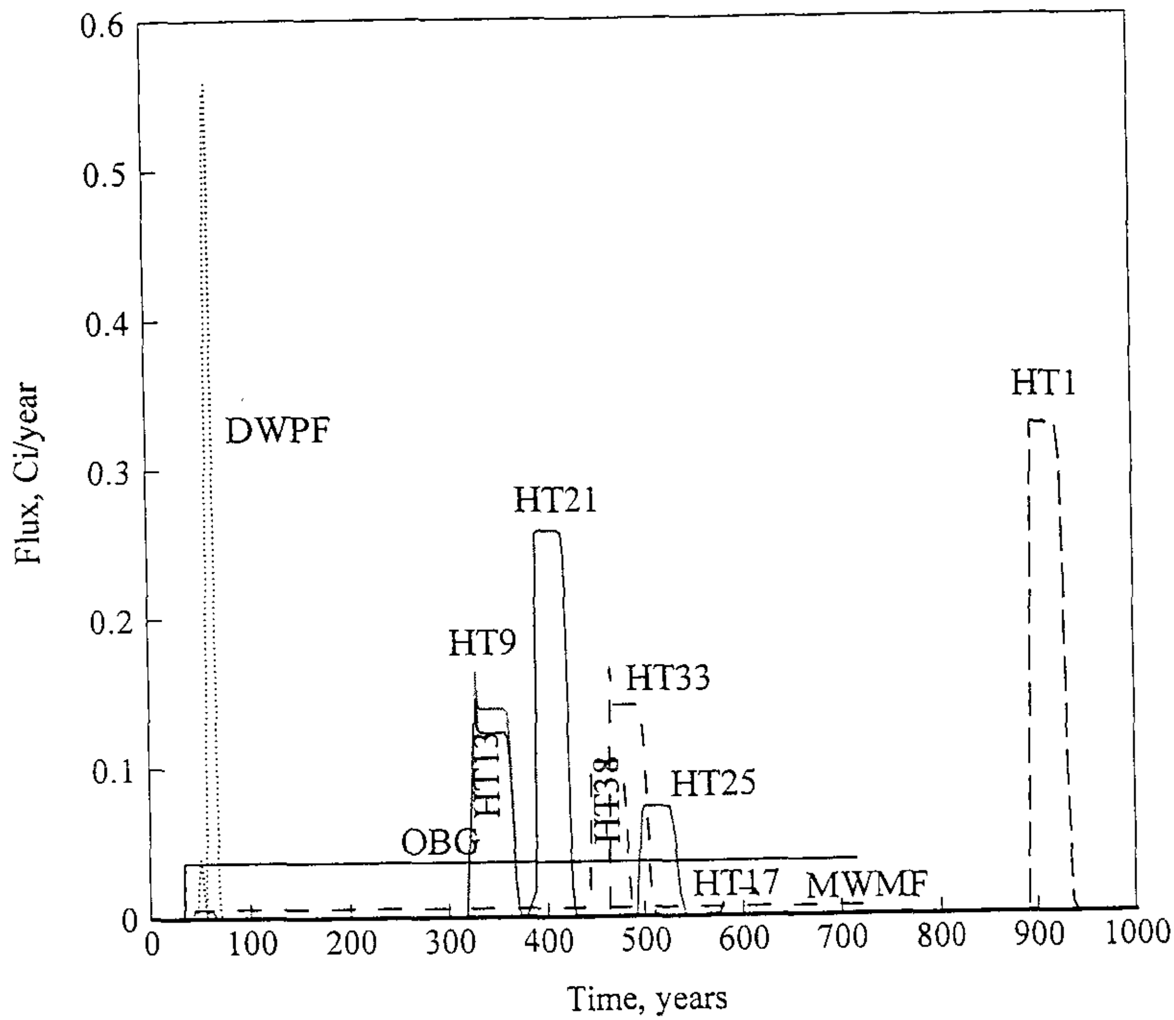

Figure 4.4-11. ^{99}**Tc flux to the water table**

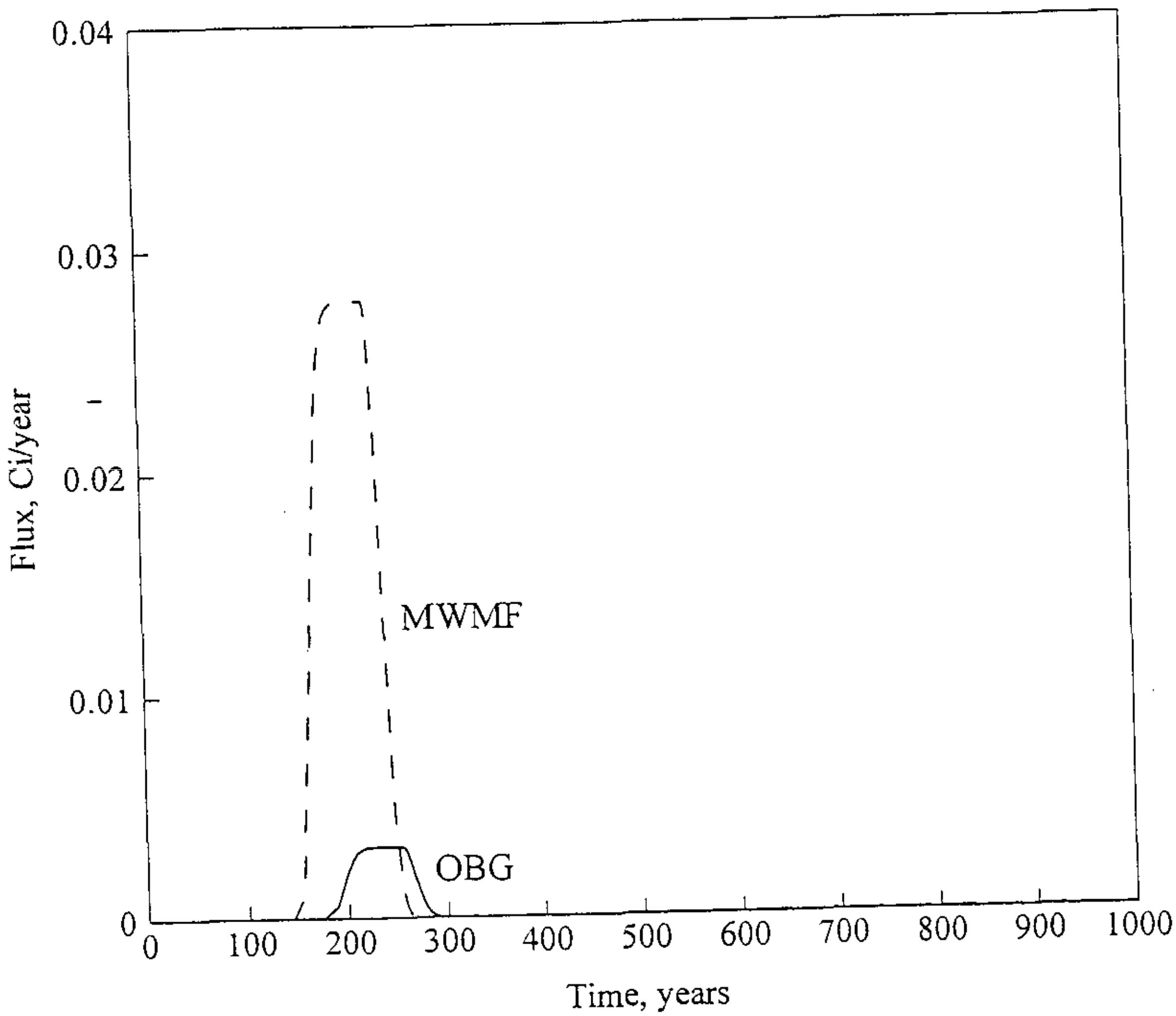

Figure 4.4-12. ^{233}**U flux to the water table**

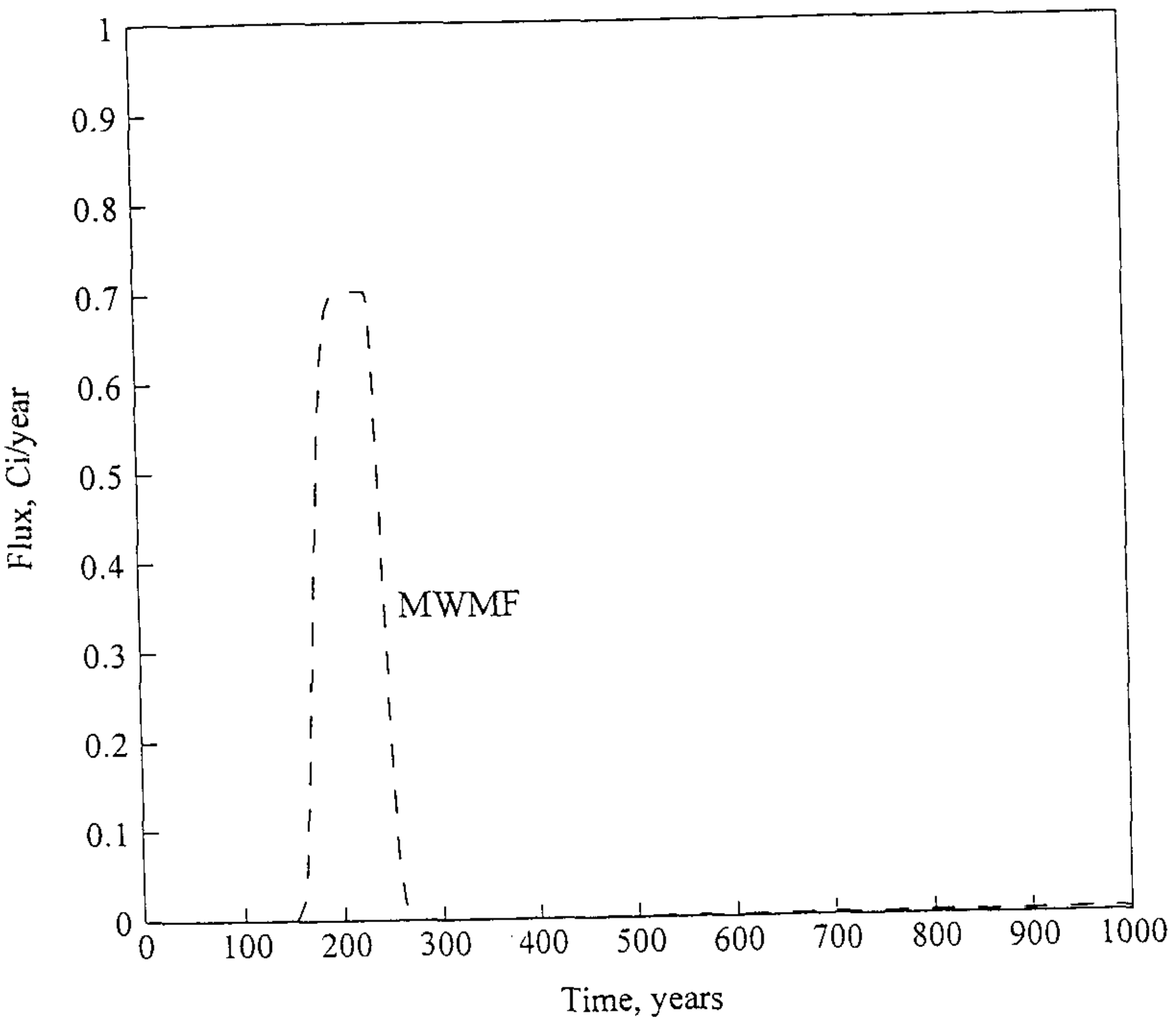

Figure 4.4-13. ^{234}**U flux to the water table**

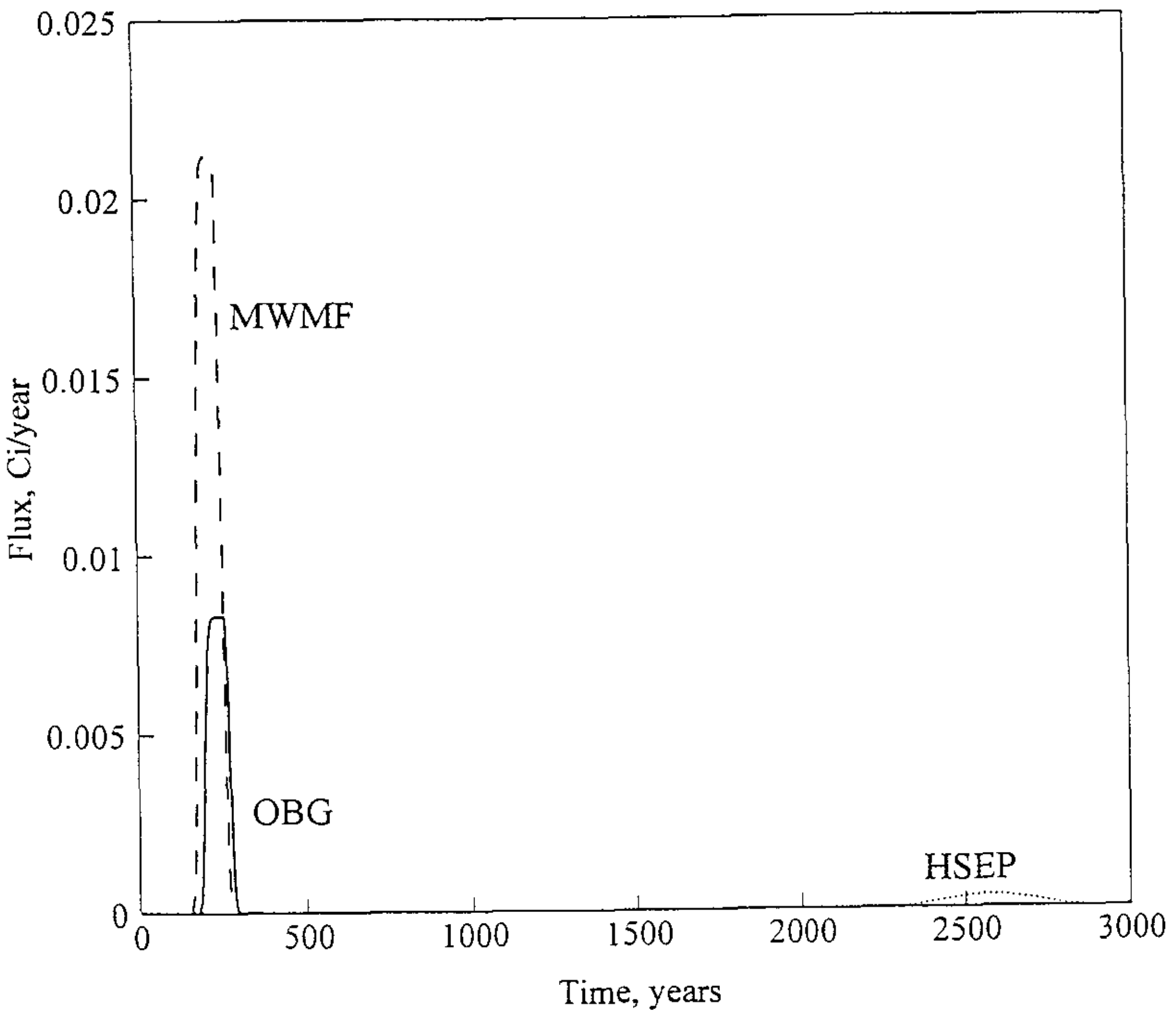

Figure 4.4-14. ^{235}U **flux to the water table**

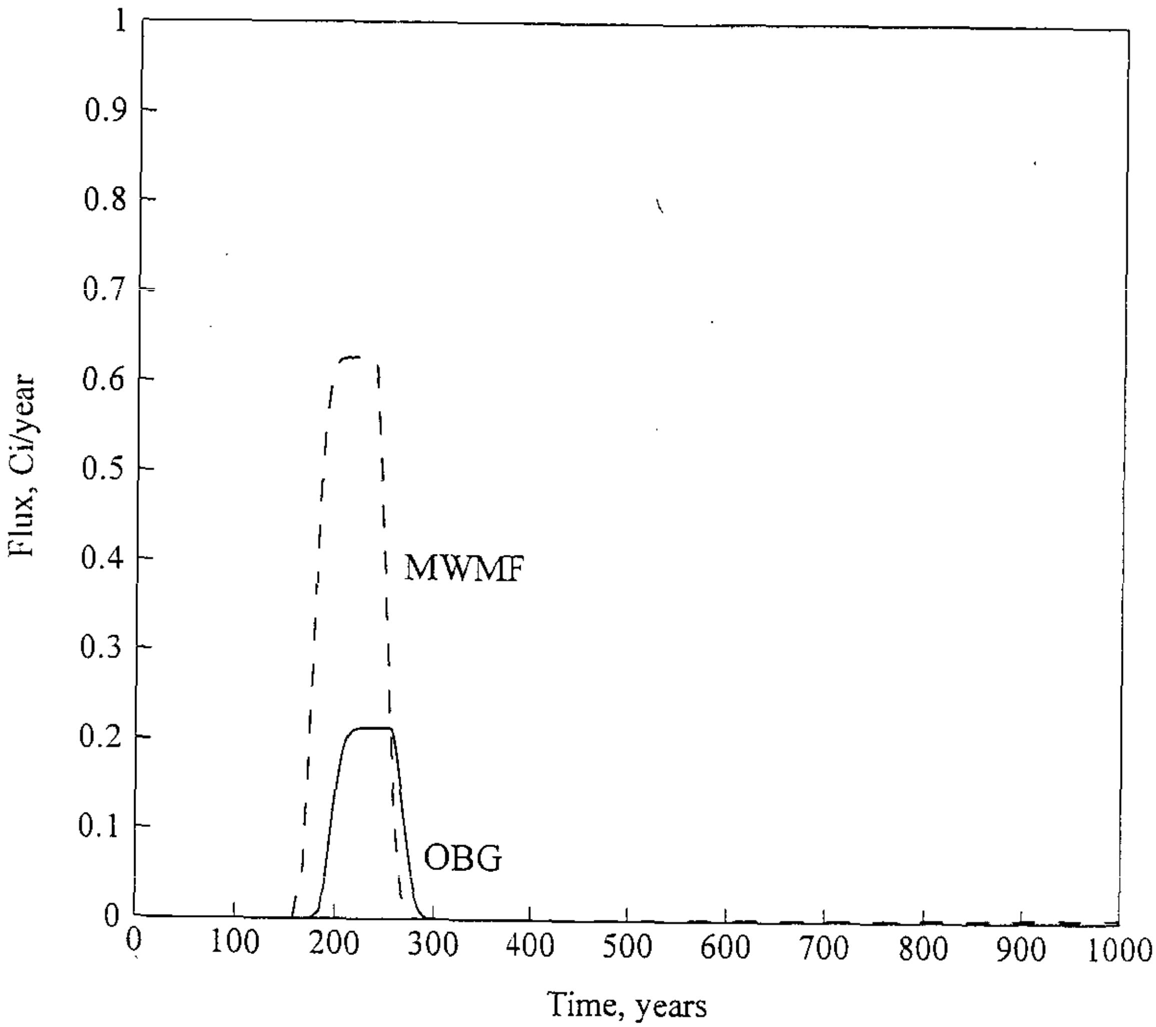

Figure 4.4-15 ^{238}U flux to the water table

Section 4.4 and augmented with potentially-significant radioactive daughters. Dose calculations were accomplished using the LADTAP XL code (Hamby, 1991a), which implements the U. S. Nuclear Regulatory Commission's Regulatory Guide 1.109 dose models.

Initially, the hypothetical individual was assumed to obtain all drinking water (730 L/yr) and all dietary fish (19 kg/yr) from a location on the Savannah River just downstream of the Savannah River Site (near South Carolina Highway 301). The individual was also assumed to be involved in recreational activities (boating and swimming) on the Savannah River at this location throughout the year. Flow of the Savannah River at this location is assumed to be 4000 cfs, which is considerably lower than the average flow rate of 10,500 cfs at this location, and thus provides an additional degree of conservatism in the calculated doses since dilution is underestimated.

Individual aquatic pathway doses were calculated for the radionuclides of potential concern in the Composite Analysis. The sum of these doses, for all of these radionuclides released at 1 Ci/yr, is approximately 32 mrem/yr. However, other creeks with flows lower than those of the Savannah River are potentially impacted by activities in the General Separations Area. Although these creeks (Upper Three Runs Creek and Fourmile Branch) are on-site, and thus not available for drinking water usage and recreational usage, the screening analysis was applied to these creeks in order to ensure that the release criterion selected was conservative. If these releases had occurred to Fourmile Branch, with a minimum flow of 14 cfs, a total dose for all radionuclides (D_{FMB}) of 9.1x 10^3 mrem/yr can be estimated from

$$D_{FMB} = D_{SR} \frac{4000}{14}, \qquad \textbf{(4.4-1)}$$

where D_{SR} is the total dose (32 mrem) calculated for Savannah River usage. This ratio is valid because the only exposure parameter assumed to differ is flow rate (and thus dilution). Likewise, for Upper Three Runs, with a minimum flow of 27 cfs, a total dose (D_{UTR}) of 1,000 mrem/yr is estimated.

Taking the largest total dose attributable to discharge of 1 Ci/yr of each radionuclide to streams in the GSA vicinity (9.1 x 10^3 mrem/yr), a release criterion, corresponding to a maximum dose of 1 mrem/yr, was calculated. From

$$\frac{R_c}{1 mrem/yr} = \frac{1 Ci/yr}{9.1 \times 10^3 mrem/yr}, \qquad (4.4\text{-}2)$$

a release criterion (Rc) of 10^{-4} Ci/yr, is calculated. This release criterion corresponds to a maximum dose to a hypothetical individual of 1 mrem/yr from all radionuclides. It is highly improbable, however, that an actual dose would approach 1 mrem/yr at this release rate, given the number of conservative assumptions incorporated in development of this criterion.

The release criterion of 10^{-4} Ci/yr was applied in two ways. If the total release of all sources of a particular radionuclide to the water table was less than 10^{-4} Ci/yr during the 1000-yr assessment period (Table 4.4-5), then that radionuclide was neglected for all sources in subsequent transport and dose calculations. In some cases, however, release of a radionuclide with multiple sources was greater than 10^{-4} Ci/yr from a few sources, but much less than 10^{-4} Ci/yr from others. In those cases, only the sources characterized by releases of the radionuclide greater than 10^{-4} Ci/yr were addressed. The results are summarized in Table 4.4-6.

Table 4.4-5. Results of flux to the water table calculations up to 1,000 years

	247-F	DWPF Ci/yr	LOWPT Ci/yr	ILV Ci/yr	LAW Ci/yr	KAPL Ci/yr	SALT Ci/yr	SLIT Ci/yr
H-3		1.70E-02	1.08E-03	8.54E-08	9.79E-05	<1.E-18	3.80E-08	8.29E-01
C-14				8.38E-12	4.03E-06	3.60E-08	<1.E-18	
Ni-59		<10E-18	<10E-18	2.83E-06	2.32E-05	9.16E-03	NA	
Se-79		7.30E-03	3.65E-04	<1.E-18	<1.E-18	NA	<1.E-18	
Sr-90		9.49E-04	3.85E-03	1.89E-12	<1.E-18	<1.E-18	<1.E-18	2.31E-05
Zr-93		<1.E-18	<1.E-18	NA	NA	9.38E-06	NA	
Tc-99		5.59E-01	3.93E-02	1.73E-04	6.10E-05	<1.E-18	<1.E-18	3.14E-05
Sn-126		<1.E-18	<1.E-18	<1.E-18	<1.E-18	NA	<1.E-18	
I-129		8.79E-04	6.75E-05	2.71E-07	1.90E-07	<1.E-18	<1.E-18	2.93E-02
Cm-246				NA	<1.E-18	NA	NA	
Cf-252				<1.E-18	<1.E-18	NA	NA	
Ra-226		<1.E-18	<1.E-18	NA	NA	NA	NA	
Th-228				NA	NA	NA	NA	
Th-230		<1.E-18	<1.E-18	NA	NA	NA	NA	
Th-232		<1.E-18	<1.E-18	1.06E-05	3.00E-05	NA	NA	
U-233				<1.E-18	<1.E-18	NA	NA	
U-234	3.61E-04	3.72E-05	3.02E-06	<1.E-18	<1.E-18	NA	NA	
U-235	2.76E-06	7.69E-05	<1.E-18	<1.E-18	<1.E-18	NA	NA	
U-236	4.42E-09	2.57E-06	2.09E-07	<1.E-18	<1.E-18	NA	NA	
U-238				<1.E-18	<1.E-18	NA	NA	
Np-237		4.68E-07	3.80E-08	<1.E-18	<1.E-18	NA	NA	3.15E-09
Pu-238		<1.E-18	<1.E-18	<1.E-18	<1.E-18	NA	<1.E-18	<1.E-18
Pu-239		<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18	NA	
Pu-240		<1.E-18	<1.E-18	<1.E-18	<1.E-18	NA	NA	
Pu-241		<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18	NA	
Pu-242		<1.E-18	<1.E-18	<1.E-18	<1.E-18	NA	NA	
Am-241		<1.E-18	<1.E-18	<1.E-18	<1.E-18	NA	<1.E-18	<1.E-18
Am-243				NA	<1.E-18	NA	NA	
Cm-244		<1.E-18	<1.E-18	NA	NA	NA	NA	

Table 4.4-5. Results of flux to the water table calculations up to 1,000 years (continued)

	HSEEP	ST33-36	OBG Ci/yr	LYSIM Ci/yr	SSLYSIM Ci/yr	MWMF Ci/yr	ST1-22 Ci/yr	ST23-32 Ci/yr	247-F Ci/yr
H-3			3.60E+04		1.28E-01	6.25E+04			
C-14			1.12E+00	6.18E-02	4.43E-09	1.35E+00			
Ni-59			<10E-18		<10E-18	<10E-18			
Se-79			6.98E-03		3.89E-04	1.10E-03			
Sr-90			6.28E-04	4.95E-11	8.94E-12	7.90E-04			
Zr-93					<1.E-18				
Tc-99	4.34E-04		3.66E-02		2.62E-01	5.75E-03			
Sn-126			<1.E-18		<1.E-18	<1.E-18			
I-129	2.93E-02		3.93E-02		4.35E-05	6.21E-03			
Cm-246									
Cf-252			<1.E-18			<1.E-18			
Ra-226	3.01E-09	7.60E-08	1.42E-07	<1.E-18	1.57E-06	3.50E-07			
Th-228		9.42E-10			<1.E-18				
Th-230	1.80E-08	5.54E-07	5.30E-12	<1.E-18	<1.E-18	7.21E-11			
Th-232			<1.E-18		<1.E-18	<1.E-18			
U-233			3.16E-03		6.38E-12	2.77E-02			
U-234			<1.E-18	<1.E-18	<1.E-18	<1.E-18			3.61E-04
U-235			8.33E-03	<1.E-18	<1.E-18	<1.E-18			2.76E-06
U-236		7.90E-09	3.87E-02		<1.E-18	7.98E-02			4.42E-09
U-238			2.13E-01		4.81E-12	6.27E-01			
Np-237			1.52E-02	<1.E-18	5.69E-11	9.31E-04			
Pu-238		4.17E-08	<1.E-18	<1.E-18	<1.E-18	<1.E-18	1.04E-08	1.52E-08	
Pu-239		1.34E-08	<1.E-18	<1.E-18	<1.E-18	<1.E-18	9.14E-09	1.18E-08	
Pu-240			<1.E-18		<1.E-18	<1.E-18			
Pu-241			<1.E-18		<1.E-18	<1.E-18			
Pu-242						<1.E-18			
Am-241			<1.E-18	<1.E-18	<1.E-18	<1.E-18			
Am-243					<1.E-18	<1.E-18			
Cm-244			<1.E-18		<1.E-18	<1.E-18			

Table 4.4-5. Results of flux to the water table calculations up to 1,000 years (continued)

	HSAND Ci/yr	HLT9-12 Ci/yr	HLT13-16 Ci/yr	HLT21-24 Ci/yr	HLT38-43 Ci/yr	HLT48-51 Ci/yr	ETFTANKS Ci/yr	TRIT Ci/yr	FSEEP Ci/yr
H-3							2.52E-02	6.30E+03	
C-14		1.95E-07	7.07E-08	1.16E-07	1.36E-07	3.69E-09			
Ni-59		8.36E-06	7.02E-06	<10E-18	<10E-18	<10E-18			
Se-79		9.73E-04	8.68E-04	1.84E-03	<1E-18	<1E-18			
Sr-90		1.22E-02	1.03E-02	<1.E-18	<1.E-18	<1.E-18	3.84E-10		
Zr-93									
Tc-99		1.65E-01	1.46E-01	2.58E-01	1.06E-01	9.49E-04			6.05E-05
Sn-126		4.70E-05	4.18E-05	<1.E-18	<1.E-18	<1.E-18			
I-129		4.08E-07	3.68E-07	6.73E-07	2.59E-07	2.83E-09	5.06E-06		6.80E-04
Cm-246									
Cf-252									
Ra-226		1.51E-10	2.34E-10	2.74E-18	<1.E-18	<1.E-18	2.73E-13		4.66E-09
Th-228									
Th-230		8.16E-10	1.27E-09	4.03E-17	<1.E-18	<1.E-18	1.87E-12		1.88E-08
Th-232		1.04E-15	1.62E-15	<1.E-18	<1.E-18	<1.E-18			
U-233		2.36E-05	2.73E-05	2.79E-05	<1.E-18	<1.E-18			
U-234		3.65E-06	5.48E-06	1.35E-05	<1.E-18	<1.E-18			
U-235	<1.E-18	2.08E-07	1.74E-07	2.47E-07	<1.E-18	<1.E-18			
U-236		3.90E-04	2.96E-04	2.71E-06	<1.E-18	<1.E-18			
U-238		4.04E-06	2.39E-06	1.06E-06	<1.E-18	<1.E-18			
Np-237		7.89E-03	2.62E-02	2.28E-06	<1.E-18	<1.E-18			
Pu-238		1.25E-08	1.94E-08	<1.E-18	<1.E-18	<1.E-18			
Pu-239	6.88E-07	1.94E-08	3.01E-08	<1.E-18	<1.E-18	<1.E-18			
Pu-240		4.18E-05	3.18E-05	<1.E-18	<1.E-18	<1.E-18			
Pu-241		8.60E-17	1.34E-16	<1.E-18	<1.E-18	<1.E-18			
Pu-242		<1.E-18	1.98E-09	<1.E-18	<1.E-18	<1.E-18			
Am-241		5.97E-18	7.70E-18	<1.E-18	<1.E-18	<1.E-18			
Am-243									
Cm-244		<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18			

Table 4.4-5. Results of flux to the water table calculations up to 1,000 years (continued)

	F-Canyon Ci/yr	FSAND Ci/yr	HLT1-8 Ci/yr	HLT17-20 Ci/yr	HLT25-28 Ci/yr	HLT33-34 Ci/yr	235-F Ci/yr	772-F Ci/yr	H Canyon Ci/yr
H-3	9.20E+00							1.57E+00	2.95E-01
C-14	6.07E-06		<10E-18	<10E-18	2.98E-07				9.25E-08
Ni-59	<10E-18		<10E-18	<10E-18	<10E-18	<10E-18			<10E-18
Se-79	2.38E-03		<10E-18	<10E-18	<10E-18	<10E-18		1.09E-07	3.59E-05
Sr-90	<1E-18		<1E-18	<1E-18	<1E-18	<1E-18		<1E-18	6.83E-06
Zr-93									
Tc-99	3.74E-01		3.28E-01	1.70E-02	7.36E-02	1.43E-01		1.65E-05	5.62E-03
Sn-126	<1.E-18		<1.E-18	<1.E-18	<1.E-18	<1.E-18		<1.E-18	<1.E-18
I-129	3.69E-04		<1.E-18	5.94E-08	2.53E-07	5.12E-07		2.33E-07	
Cm-246	<1.E-18								
Cf-252									
Ra-226	5.10E-12		<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18	5.33E-15
Th-228									
Th-230	1.54E-16		<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18
Th-232	<1.E-18		<1.E-18	<1.E-18	<1.E-18	<1.E-18		<1.E-18	<1.E-18
U-233	3.82E-12								5.73E-14
U-234	3.80E-06.		<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18		3.59E-06
U-235	6.63E-08	<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18			4.94E-08
U-236	7.21E-07		<1.E-18	<1.E-18	<1.E-18	<1.E-18		<1.E-18	<1.E-18
U-238	1.29E-06		<1.E-18	<1.E-18	<1.E-18	<1.E-18		<1.E-18	2.15E-09
Np-237	1.09E-07		<1.E-18	<1.E-18	<1.E-18	<1.E-18	3.69E-04	<1.E-18	1.10E-05
Pu-238	<1.E-18						<1.E-18	<1.E-18	<1.E-18
Pu-239	<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18	<1.E-18		<1.E-18	<1.E-18
Pu-240	<1.E-18		<1.E-18	<1.E-18	<1.E-18	<1.E-18		<1.E-18	<1.E-18
Pu-241	<1.E-18		<1.E-18	<1.E-18	<1.E-18	<1.E-18		<1.E-18	<1.E-18
Pu-242	<1.E-18		<1.E-18	<1.E-18	<1.E-18	<1.E-18			<1.E-18
Am-241	<1.E-18		<1.E-18	<1.E-18	<1.E-18	<1.E-18		<1.E-18	
Am-243	<1.E-18								
Cm-244	<1.E-18		<1.E-18	<1.E-18					

Table 4.4-6 Results of Source Term Screening

Radionuclide	Daughters	Sum of Peak Releases to the Water Table Up to 1000 yr (Ci/yr)	Screening Results
Am-241		$1.27x10^{-17}$	Exclude[a]
	Np-237	included with Np-237 parent	
Am-243		$<10^{-18}$	Exclude[a]
	Np-239	$<10^{-18}$	Exclude[a]
	Pu-239	included with Pu-239 parent	
C-14		2.53	Include
Cm-244		$<10^{-18}$	Exclude[a]
	Pu-240	included with Pu-240 parent	
	U-236	included with U-236 parent	
Cm-246		$<10^{-18}$	Exclude
Fe-55		$<10^{-18}$ [b]	Exclude
H-3		$1.05x10^{5}$	Include
I-129		$7.69x10^{-2}$	Include
K-40		$<10^{-18}$	Exclude
Mo-93		$7.4x10^{-7}$	Exclude
	Nb-93m	$<7.4x10^{-7}$ [c]	Exclude
Nb-93m		$<10^{-18}$ [b]	Exclude
Nb-94		$<10^{-18}$	Exclude
Ni-59		$1.54x10^{-5}$	Exclude
Np-237		$5.06x10^{-2}$	Include
	Pa-233	$5.06x10^{-2}$ [d]	Include
	U-233	included with U-233 parent	

Table 4.4-6 Results of Source Term Screening (continued)

Radionuclide	Daughters	Sum of Peak Releases to the Water Table Up to 1000 yr (Ci/yr)	Screening Results
Pu-238		3.19×10^{-8}	Exclude[a]
	U-234	included with U-234 parent	
	Th-230	included with Th-230 daughter of U-234 parent	
	Ra-226	included with Ra-226 parent	
	Pb-210	included with Ra-226 parent	
	Bi-210	included with Ra-226 parent	
	Po-210	included with Ra-226 parent	
Pu-239		8.22×10^{-7}	Exclude[a]
	U-235	included with U-235 parent	
Pu-240		7.36×10^{-5}	Exclude[a]
	U-236	included with U-236 parent	
Pu-241		2.2×10^{-16}	Exclude[a]
	Am-241	included with Am-241 parent	
	Np-237	included with Np-237 parent	
Pu-242		1.98×10^{-9}	Exclude
Ra-226		2.15×10^{-6}	Exclude[a]
	Pb-210	2.15×10^{-6} [d]	Exclude
	Bi-210	2.15×10^{-6} [d]	Exclude
	Po-210	2.15×10^{-6} [d]	Exclude
Se-79		2.22×10^{-2}	Include
Sn-126		8.88×10^{-5}	Exclude
Sr-90		2.87×10^{-2}	Include
Tc-99		2.52	Include
Th-232		1.66×10^{-15}	Exclude
U-233		3.09×10^{-2}	Include

Table 4.4-6 Results of Source Term Screening (continued)

Radionuclide	Daughters	Sum of Peak Releases to the Water Table Up to 1000 yr (Ci/yr)	Screening Results
U-234		4.31×10^{-4}	Include
	Th-230	5.91×10^{-7}	Exclude
	Ra-226	included with Ra-226 parent	
	Pb-210	included with Ra-226 parent	
	Bi-210	included with Ra-226 parent	
	Po-210	included with Ra-226 parent	
U-235		8.41×10^{-3}	Include
	Th-231	8.41×10^{-3} [d]	Include
	Pa-231	$< 1.68 \times 10^{-4}$	Include
	Ac-227	$<1.68 \times 10^{-4}$	Include
U-236		1.19×10^{-1}	Include
U-238		8.4×10^{-1}	Include
	Th-234	8.4×10^{-1} [d]	Include
	U-234	included with U-234parent	
Zr-93		$<10^{-18}$	Exclude
	Nb-93m	$<10^{-18}$	Exclude

[a] Consider radioactive daughter fluxes at water table, which may be significant with respect to release criterion.

[b] Naval reactor source; casks assumed intact for 750 years. Radioactive decay renders the inventories of these radionuclides insignificant inventories by that time.

[c] The Nb-93m daughter of Mo-93 will not exceed the parent activity during the 1000-yr assessment period; flux at water table will be less than that of Mo-93, due to stronger sorption.

[d] The radioactive daughter is assumed to be in secular equilibrium with the parent, and travel with the parent; thus, the fluxes to the water table are assumed to be the same.

5.0 PERFORMANCE ANALYSIS

The purpose of this section is to describe the methodology used to assess migration of radionuclides from their sources in the GSA to the points of assessment, defined in Section 2.4.1. Several analytical and numerical tools were used in this analysis.

The flow diagram in Fig. 5.0-1 describes how these tools were linked to carry out the required computations. In Section 4.4.1, the development of the inventory estimate for all facilities was described. This information was screened according to procedures described in Section 4.4.2, in order to identify radionuclides of potential significance in the Composite Analysis. The PATHRAE code was then used to develop an estimate of the flux of each radionuclide to the water table (Section 4.4.3) through application of analytical solutions to unsaturated flow and transport problems (Appendix D). The flux to the water table was used as the mass source term for the PORFLOW code. The PORFLOW code is capable of computing flow and mass transport in the saturated zone; however, for the Composite Analysis, the numerical flow simulations were accomplished with the FACT code (Section 5.1 below) because a flow field specific to the GSA had previously been developed and calibrated using this code. This flow field, which provides flow velocity and directions in the saturated zone, was used as input to the PORFLOW code for mass transport calculations (Section 5.2). The output from the PORFLOW code was in terms of flux of radionuclides to the Upper Three Runs and Fourmile Branch streams. These fluxes to the streams were utilized by the LADTAP XL code in calculating surface water concentrations (Section 5.3) and maximum individual and population doses (Sections 5.4 and 5.5).

5.1 Hydrologic Model

The GSA model simulates groundwater flow within the area bounded by Fourmile Branch on the south, Upper Three Runs on the north, F Area on the west, and McQueen Branch on the east (Figure 5.1-1) from ground surface to the bottom of the Gordon

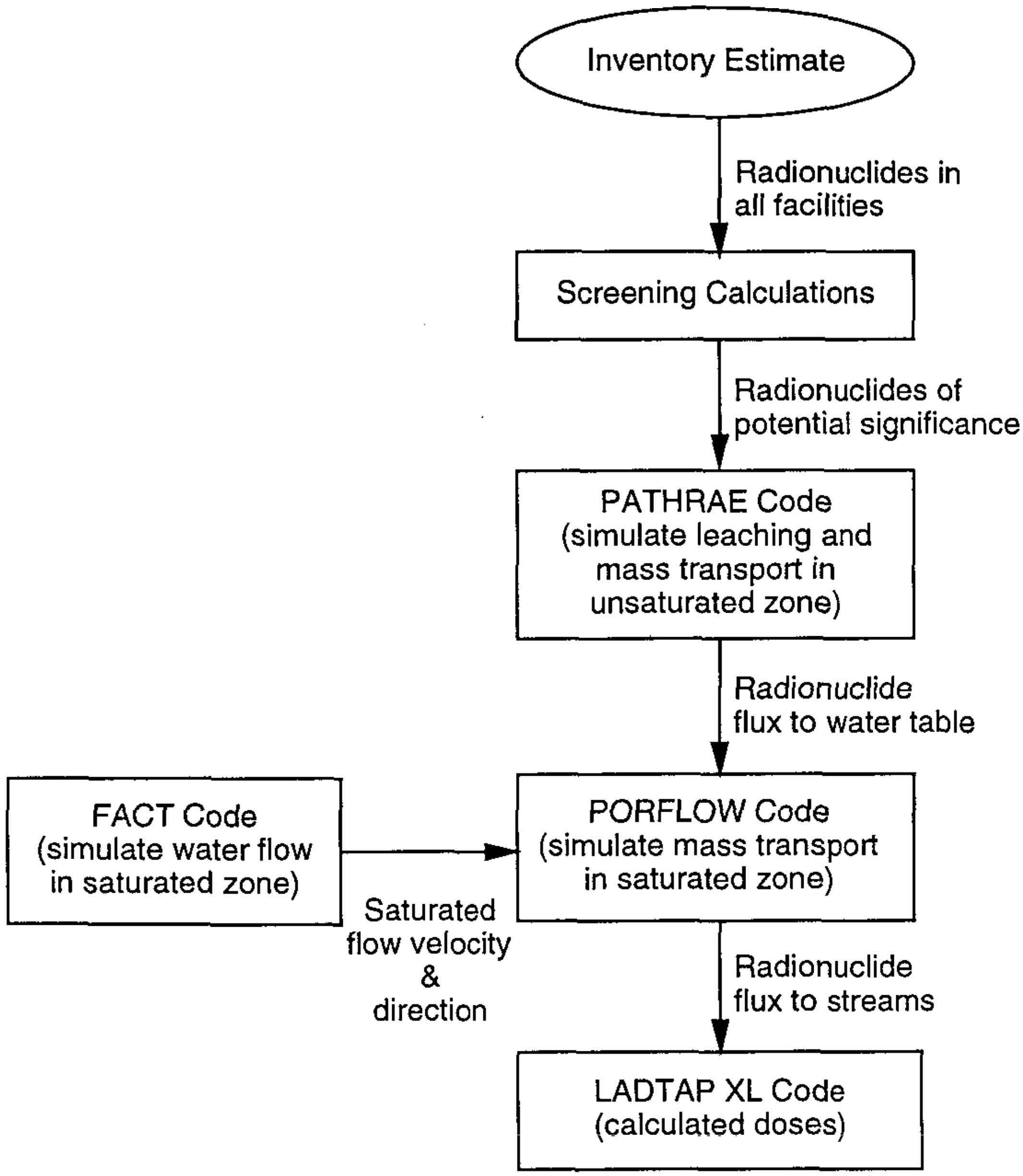

Figure 5.0 Model Flow Diagram

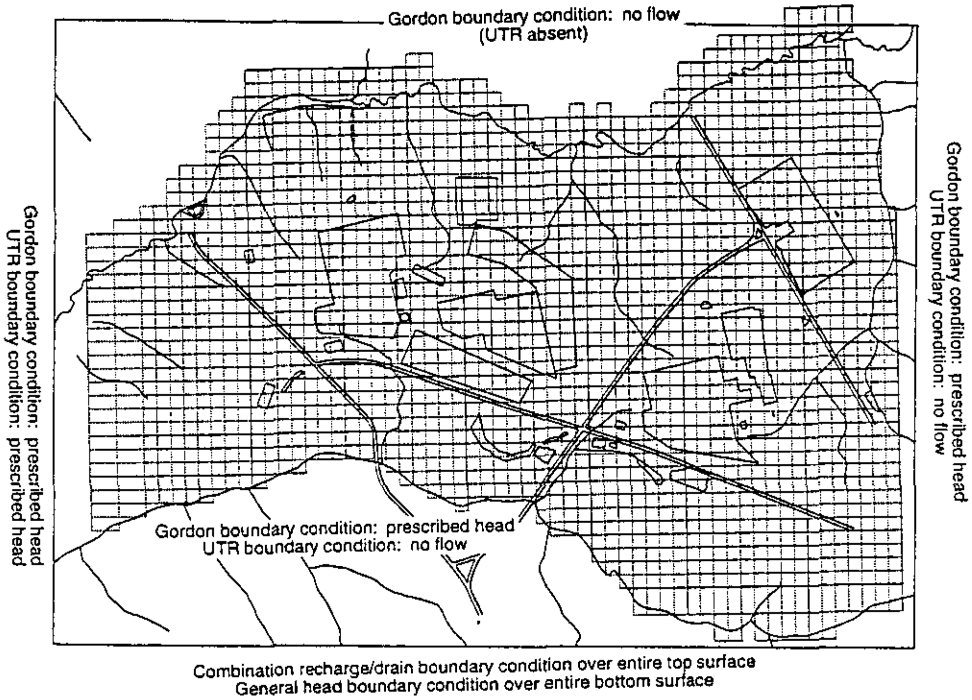

Figure 5.1-1 Active mesh elements

aquifer (Figure 5.1-2). The aquifer system potentially impacted by radionuclides released from sources in the GSA is the Floridian aquifer system (Section 2.3.5), which is comprised of two aquifer units: the Upper Three Runs aquifer unit and the Gordon aquifer unit. Boundary conditions for the two aquifer units of concern in this analysis were defined according to the following rationale.

From the discussion in Section 2.3.5.2, most of the groundwater from the Upper Three Runs (UTR) aquifer unit discharges to Upper Three Runs, Fourmile Branch and McQueen Branch. Because these streams incise this unit, the remaining groundwater moves downward across the Gordon confining unit. Therefore, these streams provide natural boundary conditions for most of the UTR aquifer unit, and were prescribed as discharge regions in the groundwater model. On the west side of the unit, hydraulic head values from a contour map of measured groundwater elevations are prescribed in lieu of natural flow boundaries.

Hydraulic head measurements indicate that the Gordon aquifer discharges fully to Upper Three Runs in the vicinity of the GSA (Section 2.3.5.2); therefore, a discharge boundary condition is specified over the north face of the model, along Upper Three Runs. Lacking natural boundary conditions, hydraulic heads are specified over the west, south and east faces of the model within the Gordon aquifer. Areas of groundwater recharge and discharge consistent with computed hydraulic head at ground surface are computed as part of the model solution using a combined recharge/drain boundary condition. In areas where the computed head lies below ground elevation, recharge occurs. Recharge to the water table is specified at an average rate of 0.37 m/yr (14.4 in/yr) over the entire model surface area. Various man-made features (e.g., basins) provide additional recharge in localized areas, which are specified. Groundwater discharges to surface water in regions where the computed head is at or above ground elevation.

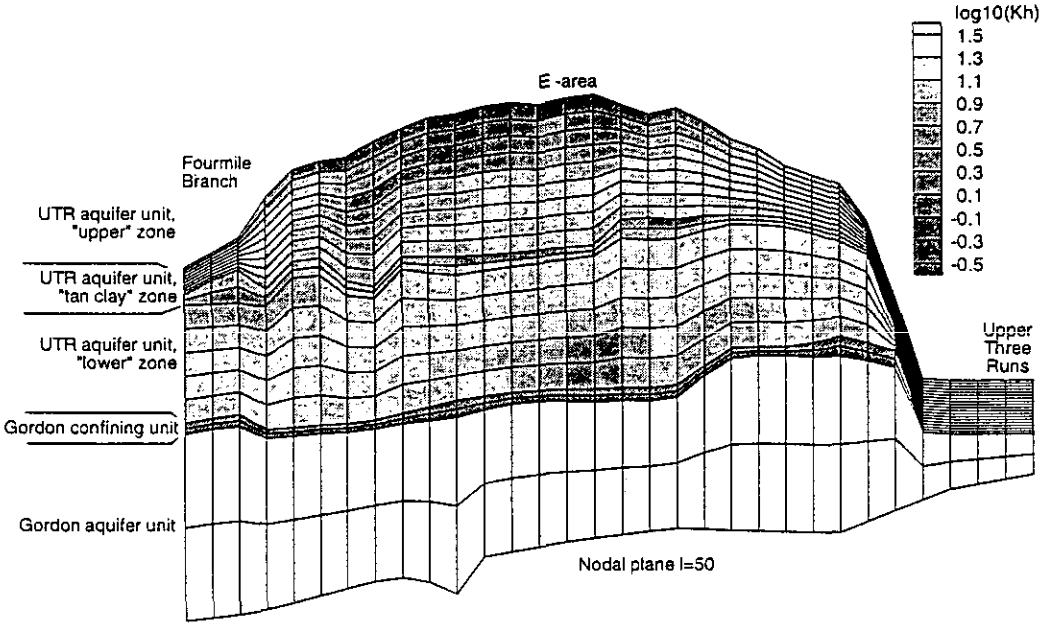

Figure 5.1-2 Typical cross-section of stratigraphy-conforming mesh and log 10 K_d field

The areal resolution of the model is 122 m^2 (400 ft^2) except in peripheral areas (Figure 5.1-1). There are 58 elements along the east-west axis, and 44 elements along the north-south axis. The vertical resolution varies depending on hydrogeologic unit and terrain/hydrostratigraphic surface variations (Figure 5.1-2). Each hydrostratigraphic surface is defined by numerous "picks" ranging in number from approximately 70 to 375 depending on the surface. The "upper" aquifer zone of Upper Three Runs aquifer unit is represented with 9 finite-elements in the vertical direction which includes the vadose zone. The "lower" aquifer zone contains 5 finite-elements while the "tan clay" confining zone separating the aquifer zones is modeled with 2 vertical elements. The Gordon confining and aquifer units each contain 2 elements, for a total of 20 vertical elements from ground surface to the bottom of the Gordon aquifer. The 3D mesh size is therefore $58\times44\times20$ = 51,040 elements or $59\times45\times21$ = 55,755 nodes. The relatively fine vertical resolution of the model is designed to support subsequent contaminant transport analyses.

Hydraulic conductivity values in the model are based directly on a large characterization database comprised of approximately 100 pumping and 500 slug test data points, approximately 250 laboratory permeability measurements, and approximately 40,000 lithology data records. The conductivity field is heterogeneous within hydrogeologic units and reflects variations present in the characterization data (Figures 5.1-2 through 5.2-7). The average horizontal conductivities in the "upper" Upper Three Runs aquifer zone, "lower" UTR aquifer zone, and Gordon aquifer unit are 2.5×10^{-5}, 3.0×10^{-5}, and 1.5×10^{-4} m/s (7.2, 8.4, and 43 ft/d), respectively. The average vertical conductivities for the "tan clay" confining zone and the Gordon confining unit are 2.5×10^{-8} and 1.5×10^{-10} m/s (7.0×10^{-3} and 4.2×10^{-5} ft/d), respectively.

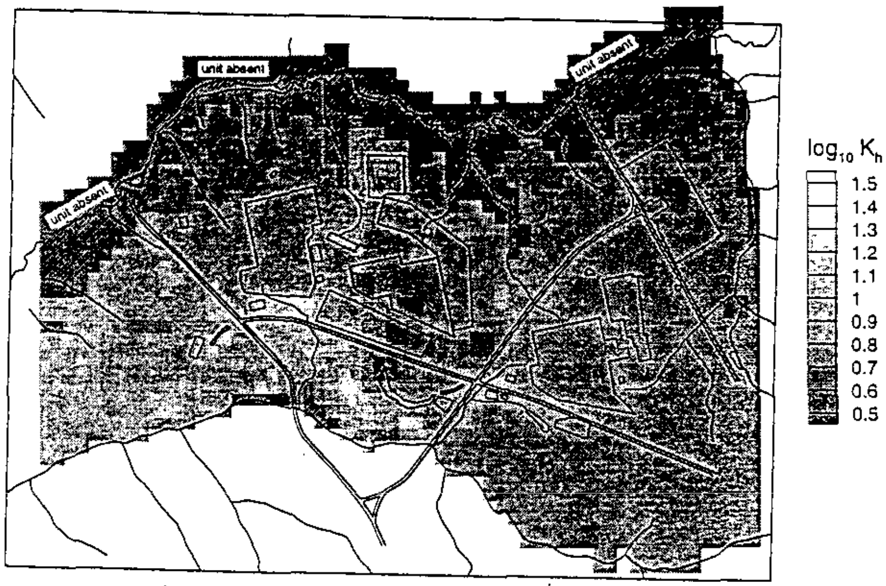

Figure 5.1-3 Simulated horizontal conductivity in the UTR Aquifer Unit "Upper" zone (vertical average)

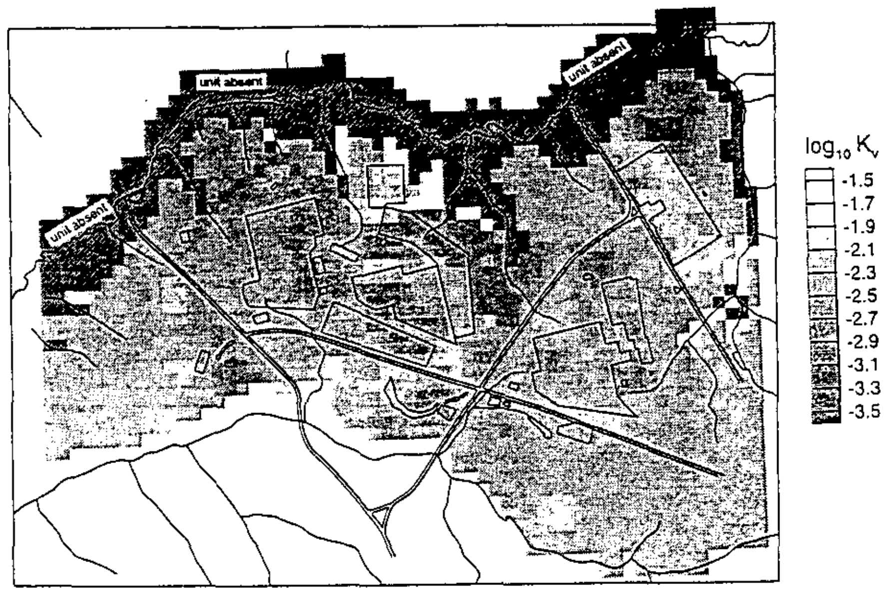

Figure 5.1-4 Simulated vertical conductivity in the UTR Aquifer Unit "Tan Clay" confining zone (vertical average)

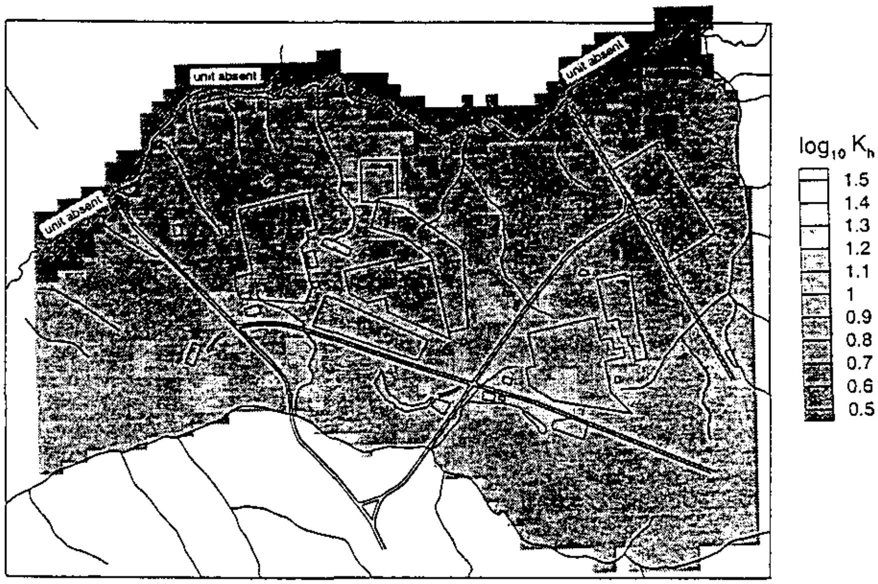

Figure 5.1-5 Simulated horizontal conductivity in the UTR Aquifer Unit "Lower" zone (vertical average)

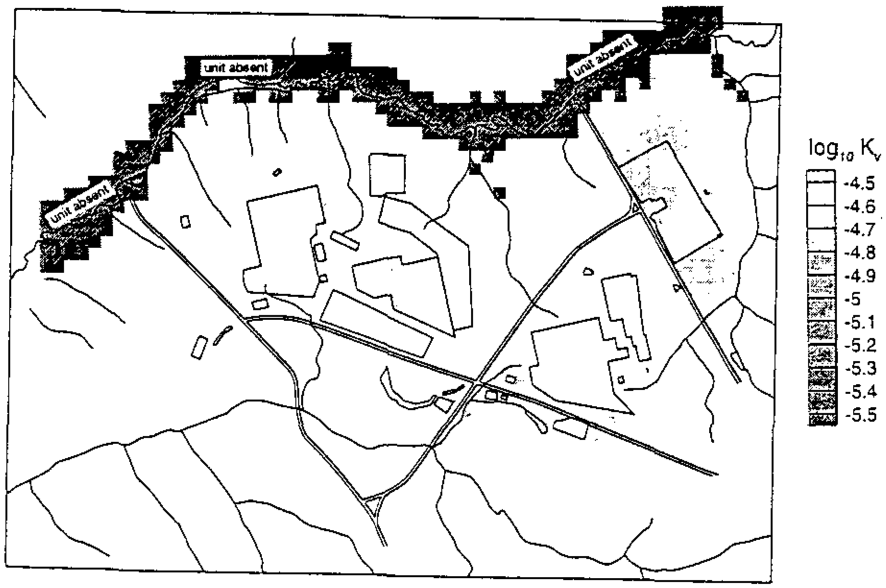

Figure 5.1-6 Simulated vertical conductivity in the Gordon Confining Unit (vertical average)

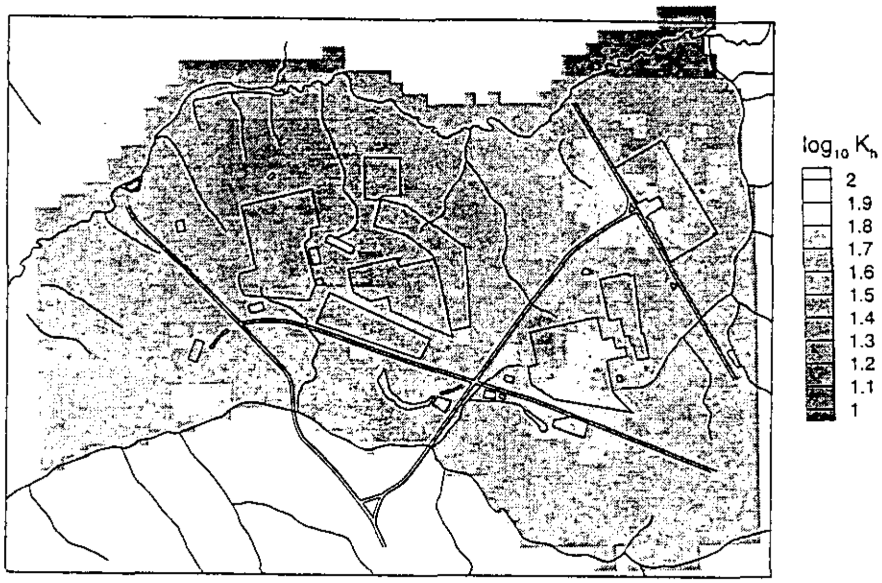

Figure 5.1-7 Simulated horizontal conductivity in the Gordon Aquifer Unit (vertical average)

Model calibration targets include hydraulic head and stream baseflow measurements. The overall root-mean-square (r.m.s.) difference between simulated head and approximately 665 time-averaged measurements is 1.37 m (4.49 ft). The r.m.s. residuals within the "upper", "lower", and Gordon aquifer zones/units are 1.2, 2.0, and 0.5 m (3.9, 6.4, and 1.7 ft), respectively; (Figures 5.1-8 through 5.1-10). Figures 5.1-11 and 5.1-12 illustrate the simulated vertically-averaged potentiometric surfaces for the aquifer zone containing the water table ("upper" and "lower" zones of the Upper Three Runs aquifer) and the Gordon aquifer unit, respectively. Measured head in the aquifer unit containing the water table is shown in Figure 5.1-13, for comparison to Figure 5.1-11. Measured head in the Gordon aquifer is shown in Figure 5.1-14, for comparison to Figure 5.1-12. These comparisons indicate that the GSA model reproduces the head gradients in the respective aquifer units fairly well, and thus should accurately simulate flow directions and rates in these units.

The estimated discharge rates to Upper Three Runs, Fourmile Branch, McQueen Branch, and Crouch Branch, based on baseflow measurements, within the model domain are 0.52, 7.3×10^{-2}, 4.2×10^{-2}, and 5.1×10^{-2} m^3/s, respectively (18.2, 2.6, 1.5, and 1.8 ft^3/s). The simulated discharge rates are 0.35, 9.6×10^{-2}, 6.2×10^{-2}, and 3.4×10^{-2} m^3/s (12.4, 3.4, 2.2, and 1.2 ft^3/s), indicating reasonable agreement with measured rates. Maps of simulated natural recharge and discharge and of man-made recharge are provided in Figures 5.1-15 and 5.1-16, respectively. Locations of predicted seepage faces are consistent with field observations (Figure 5.1-17). Figures 5.1-18 through 5.1-20 illustrate simulated flow direction vertically-averaged over the entire thickness of the "upper" Upper Three Runs, "lower" Upper Three Runs, and Gordon aquifer zones/unit. For the "upper" and "lower" zones of the Upper Three Runs aquifer unit (Figures 5.1-18 and 5.1-19), the influence of Upper Three Runs and Fourmile Branch on flow directions is evident. A groundwater divide occurs in the vicinity of the Old Burial Grounds, representing the competing influence of the two creeks. For the Gordon aquifer, the overwhelming influence of the more deeply-cutting Upper Three Runs (Section 2.3.5) is evident.

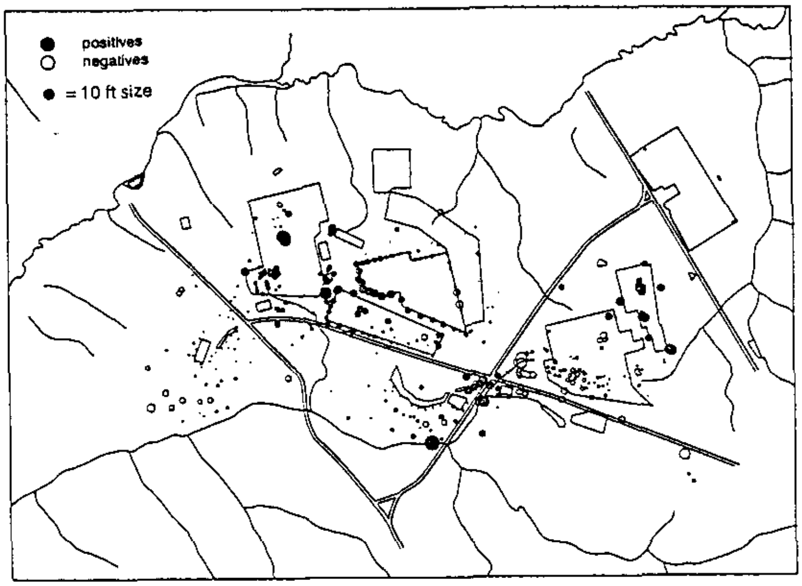

Figure 5.1-8 Head residuals in the UTR Aquifer Unit, "Upper" zone

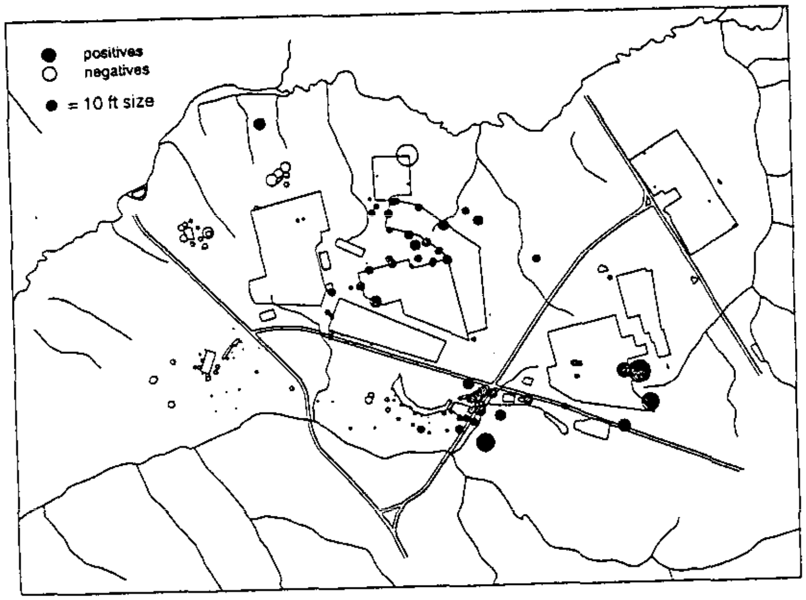

Figure 5.1-9 Head residuals in the UTR Aquifer Unit, "Lower" zone

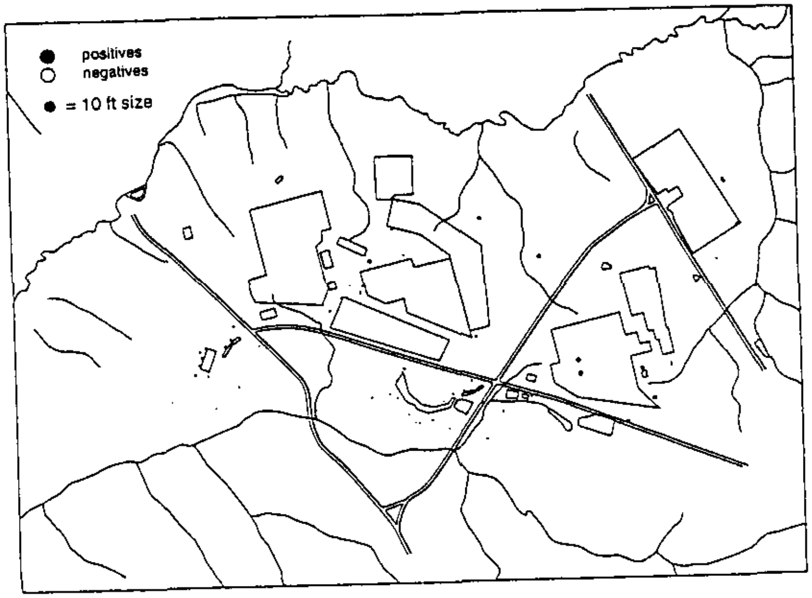

Figure 5.1-10 Head residuals in the Gordon Aquifer Unit

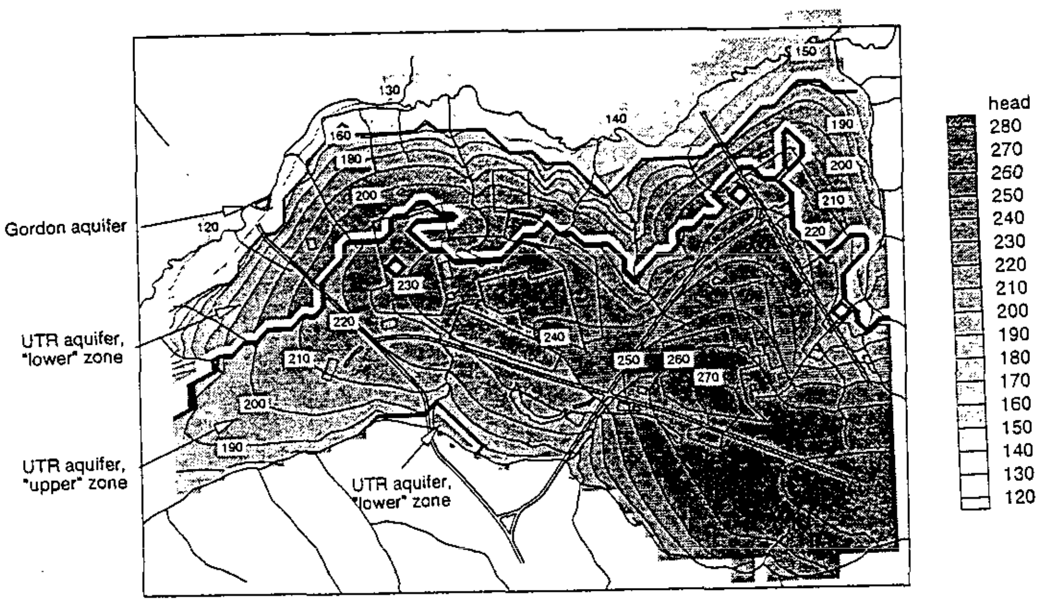

Figure 5.1-11 Simulated hydraulic head in the aquifer zone containing the water table

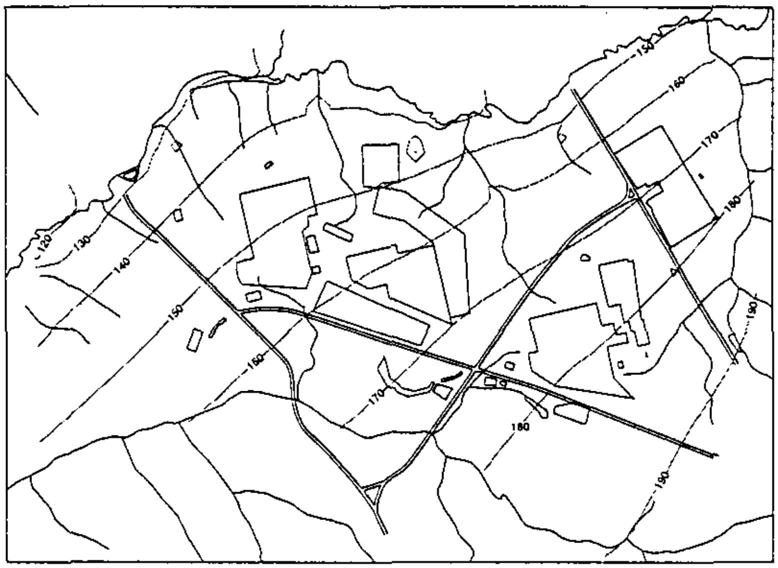

Figure 5.1-12 Simulated hydraulic head in Gordon Aquifer Unit

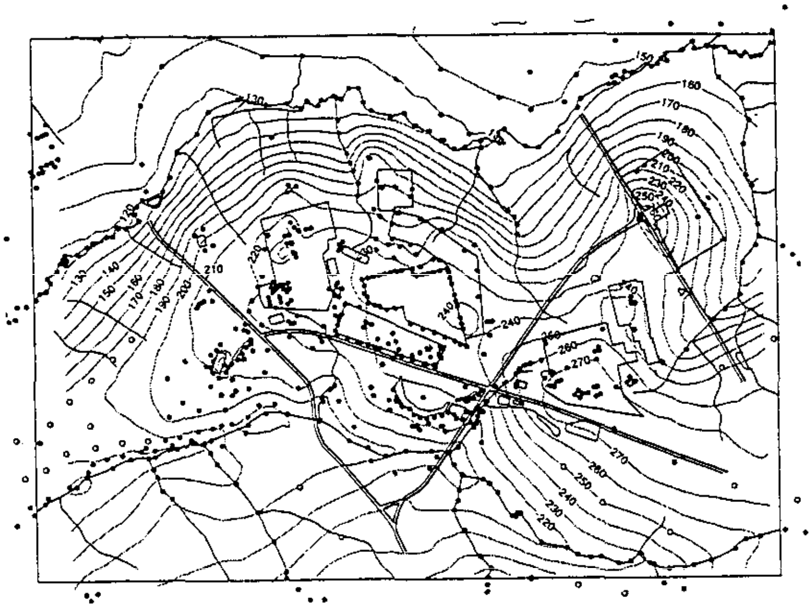

Figure 5.1-13 Measured hydraulic head in aquifer unit containing the water table

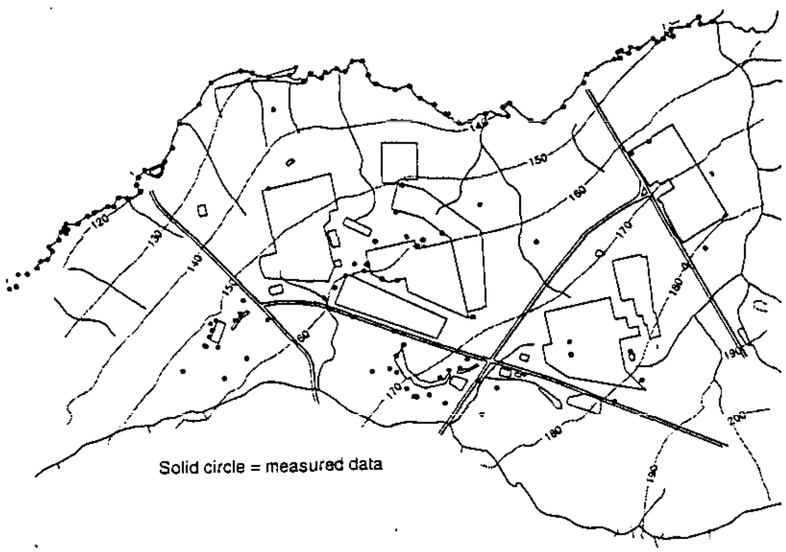

Figure 5.1-14 Measured hydraulic head in the Gordon Aquifer Unit

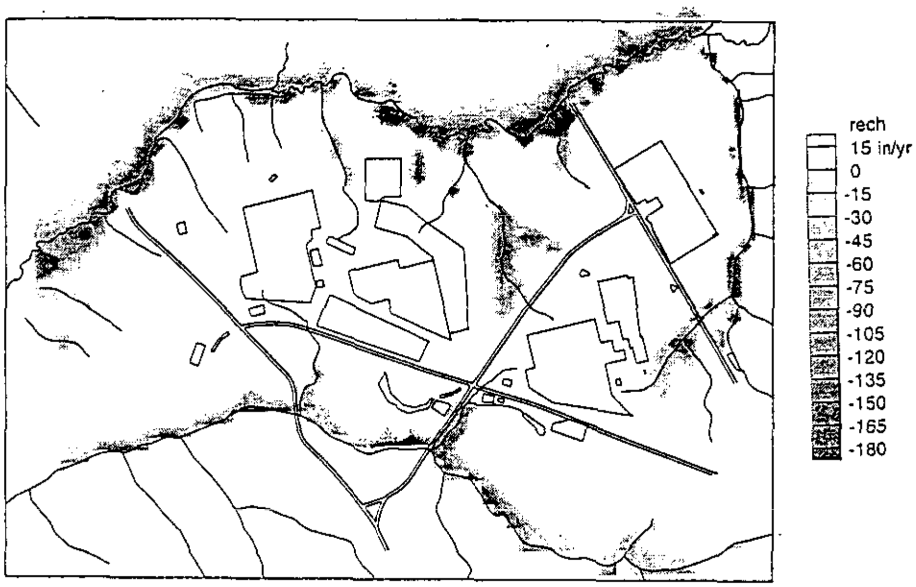

Figure 5.1-15 Simulated groundwater recharge (discharge)

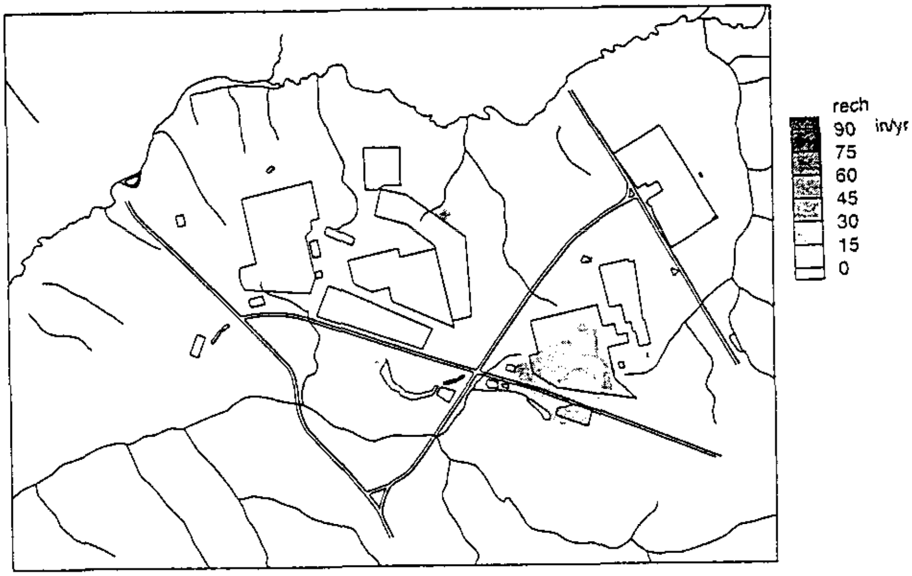

Figure 5.1-16 Simulated groundwater recharge from artificial (man-made) sources

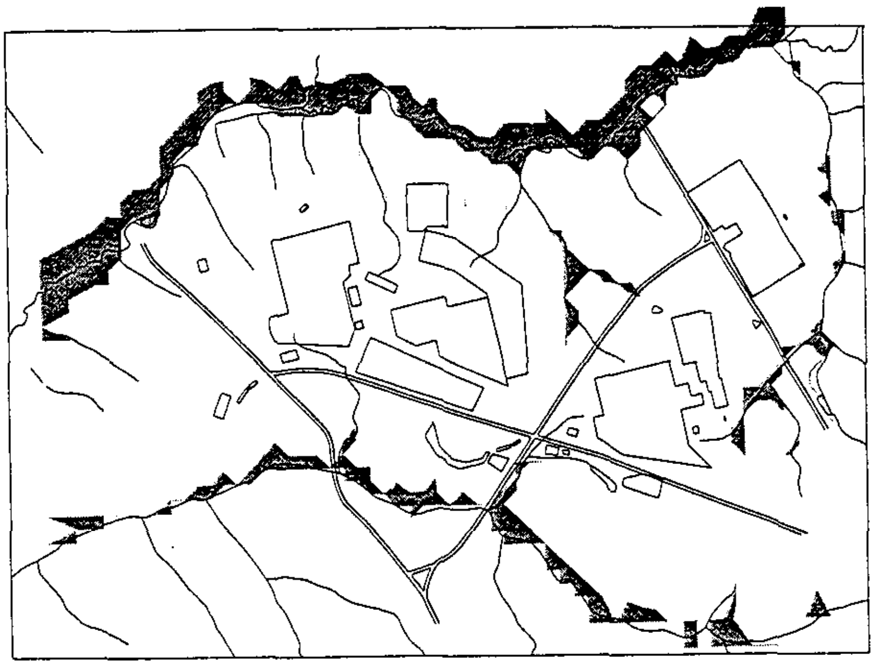

Figure 5.1-17 Simulated seepage faces

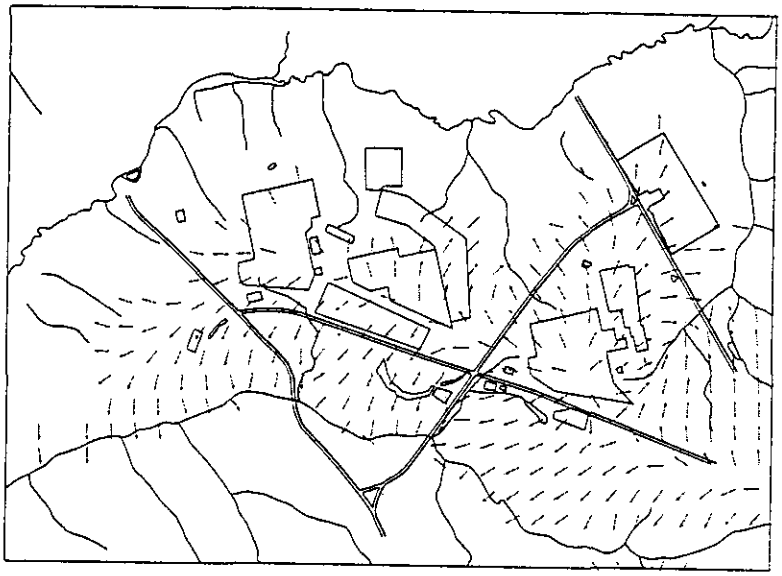

Figure 5.1-18 Groundwater flow directions in the UTR Aquifer Unit, "Upper" zone

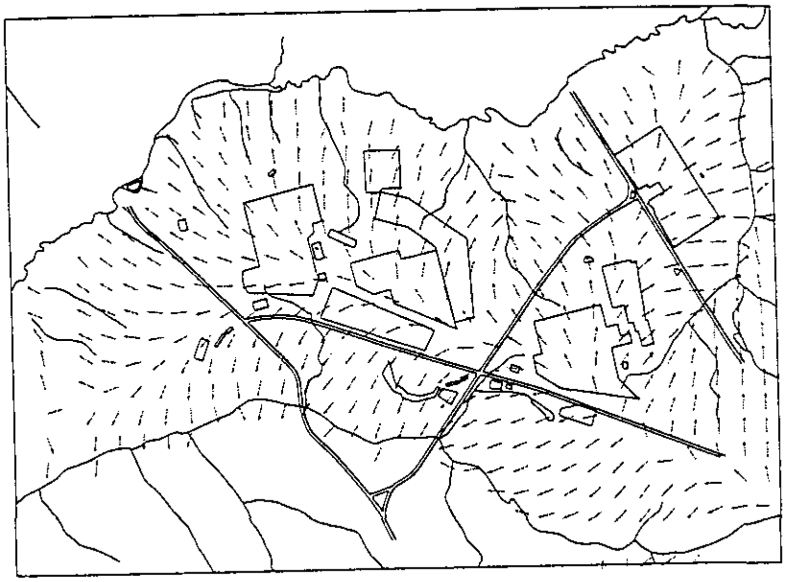

Figure 5.1-19 Groundwater flow directions in the UTR Aquifer Unit, "Lower" zone

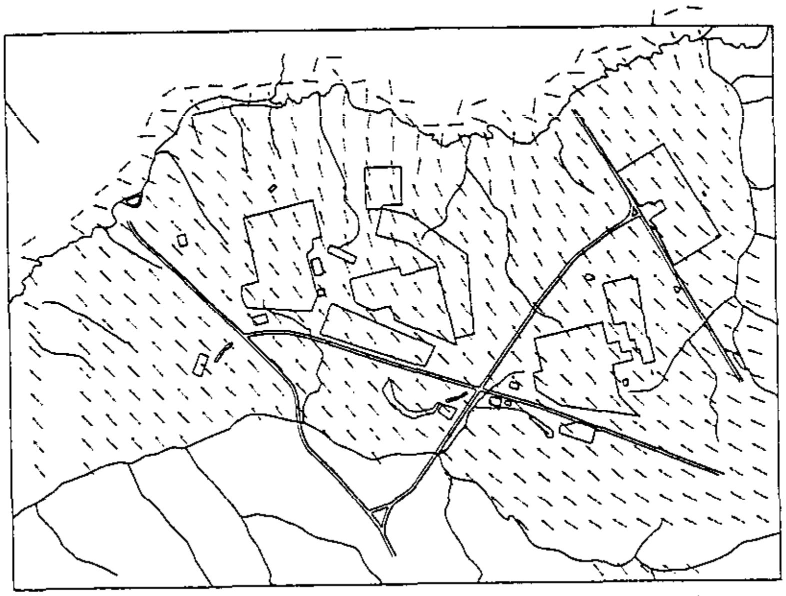

Figure 5.1-20 Groundwater flow directions in Gordon Aquifer Unit

Fourmile Branch does not incise this lower aquifer unit, and thus does not influence flow directions in this unit.

The hydrologic model described above was used to generate an annual average flow field for the GSA. This flow field describes the quantity and rate of flow of water between elements in the model grid, and is utilized in the subsurface transport model (Section 5.2) to predict movement of radionuclides from their point of contact with the water table through the groundwater to the streams in the vicinity of the GSA.

5.2 Subsurface Transport

Fluxes of contaminants at locations critical to analyzing dose at the points of assessment (Section 2.4.1) in this analysis require analysis of subsurface transport of radionuclides from the source locations identified (Section 4.1). These source locations include those addressed in the Z-Area and E-Area PAs and others in the vicinity of these low-level waste disposal areas. A discussion of the transport processes addressed, and assumptions made, in simulating these processes is given in Section 5.2.1 below. Details relevant to application of the PORFLOW code to simulate transport are provided in Section 5.2.2.

5.2.1 Transport Processes and Assumptions

Transport of radionuclides introduced to the saturated zone under the GSA occurs as a result of advective and dispersive processes, but is hindered by sorptive and radioactive decay processes. These processes are simulated in the PORFLOW fluid flow and contaminant mass transport code for the Composite Analysis.

The advection-dispersion equation implemented by PORFLOW (Appendix D.4.3) considers transport of solutes via the bulk motion of flowing groundwater, termed advective transport. Advective transport of radionuclides is estimated for the Composite

Analysis using flow fields simulated by the FACT code (Section 5.1). In order to visualize the directions of advective transport of dissolved constituents in the GSA subsurface, a particle tracking simulation was completed, the results of which are shown in Figure 5.2-1 for sources in the GSA. Using this type of analysis, a dissolved particle, representing a conservative (i.e., non-decaying and non-sorbing) tracer, is "started" at a specified location (e.g., the location of a GSA source) and tracked according to location over time. Particle tracking is used to identify flow direction and velocity for grid nodes of interest in contaminant transport simulations.

As a contaminant plume approaches a particular location, the concentration gradually, rather than abruptly, builds to the maximum concentration in the plume at that location due to dispersion. Dispersion creates plume spreading as a result of diffusion of solute molecules, and mechanical mixing. Diffusive transport, like advective transport, is simulated in PORFLOW through implementation of the advection-dispersion equation (Appendix D.4.3). In this equation, diffusion is a component of the hydrodynamic dispersion coefficient. The value of the diffusion coefficient for major ions in water at 25°C is on the order of 10^{-9} m^2/s (Freeze and Cherry 1979), and is fairly constant for most dissolved constituents in water. In porous media, however, diffusion rates are decreased due to the tortuous paths that ions must follow. Therefore, an apparent diffusion coefficient of 10^{-10} m^2/s was used in this analysis, reflecting a tortuosity factor of 0.1, which is within the commonly observed range of 0.5 to 0.01 (Freeze and Cherry 1979). In the saturated zone at the SRS, however, advective transport of groundwater constituents is sufficiently high to render diffusive transport relatively insignificant.

Mechanical dispersion, which causes spreading of a contaminant plume, is a property of the aquifer matrix and flow characteristics. Dispersion increases with heterogeneity, fracturing of the aquifer matrix, and flow rate. In PORFLOW, mechanical dispersion coefficients are components of the hydrodynamic dispersion coefficient in the advection-dispersion equation. For this analysis, mechanical dispersion was neglected, and thus

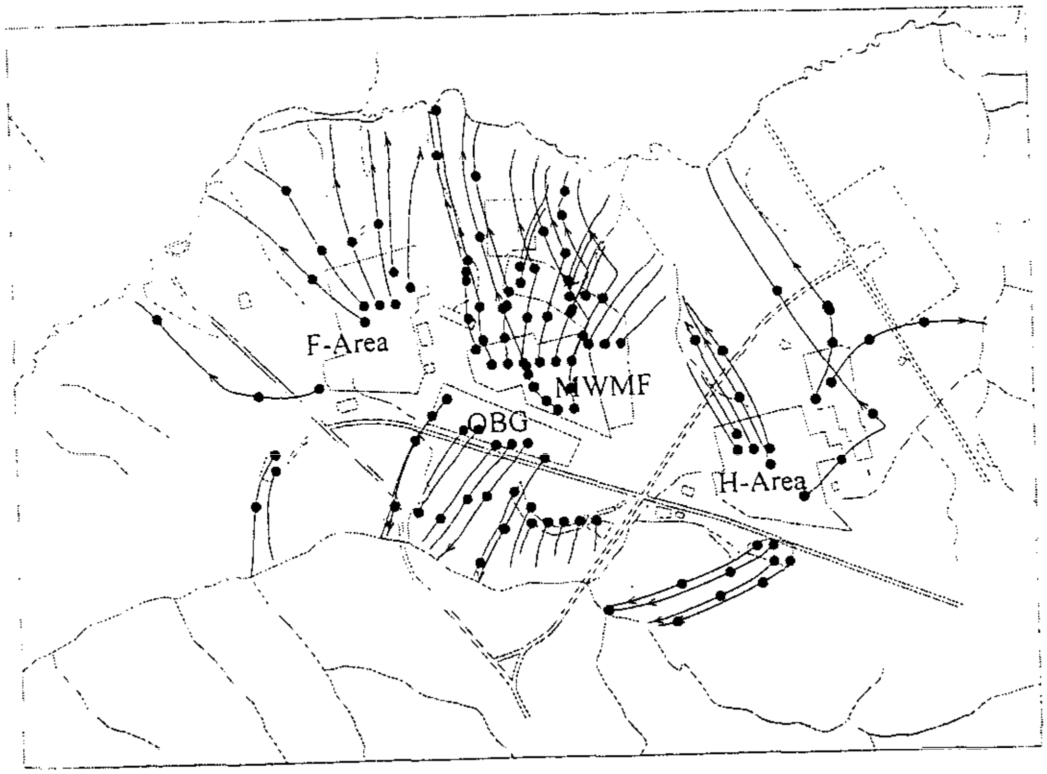

Figure 5.2-1 Particle tracking for the major contaminant sources

dispersion coefficients were set to zero. Although mechanical dispersion may result in the dilute portion of a plume reaching a particular location somewhat earlier in time, neglect of this process is not expected to lead to underestimates of radionuclide concentrations for the following reasons. First, the time period of this assessment is 1000 years; this amount of time is sufficient for arrival of the more concentrated portion of the plume at the location of concern, and thus the more dilute front edge is not significant with respect to the resulting peak concentrations that are used in calculating doses. Second, some numerical dispersion is unavoidable in this analysis, because of computing limitations in dealing with the large grid blocks used for the GSA model. Numerical dispersion, the effects of which are not discernible from mechanical dispersion in numerical analysis, occurs when a grid element is larger than the distance a molecule may travel by advection in one time step of simulation. Since the amount of solute in that grid element at the end of the time step is averaged over the grid element, some artificial spreading and dilution of the front edge of the plume occurs under these conditions.

Sorption of contaminants on solid surfaces is often viewed as reversible, achieving equilibrium instantaneously, and applies only to immobile surfaces (i.e., sorption on mobile colloids is not considered - see Section 4.3). This view of sorption is represented by a sorption coefficient, K_d, and is the view adopted for the Composite Analysis. Sorption coefficients are radionuclide- and media-specific, and are included in the governing equation for mass transport which is implemented by PORFLOW (Appendix D.4.3). Radionuclides that are sorbed on solid media appear to be retarded in their movement, but maximum concentrations downstream are not necessarily reduced below the initial plume concentration unless the radionuclides decay appreciably as a result of retardation before arrival at the point of interest downstream.

The value of K_d varies with the contaminant and the media to a large degree. The values used for the mass transport simulations using PORFLOW are given in Table 4.4-6. These values are site-specific when possible, and are recommended values from literature sources when necessary. Sources of each K_d value are provided in Table 4.4-6. Sorption coefficients for soil were applied in this analysis when the vertical hydraulic conductivity (K_v) of the media in a grid element is greater than or equal to 1×10^{-9} m/s; a clay K_d is used when the K_v is less than 1.0×10^{-9} m/s. The criteria of 1×10^{-9} m/s for K_v corresponds to a 50 percent mud fraction in aquifer sediments; lower values of K_v correspond to mud fractions greater than 50 percent. This value was selected based on the knowledge that grid elements representing the Gordon confining unit, which is the only continuous confining unit in the hydrologic units of concern, are generally characterized by a K_v less than 1×10^{-9} m/s. Thus, the higher sorption capacity of clay is accounted for only in this confining unit, even though intermittent clay lenses exist in other hydrologic units. This adds conservatism to the transport modeling, by neglecting the greater sorption capacity of non-contiguous clays in the hydrologic units.

During transport and while sorbed, radionuclides are decaying at an exponential rate determined by their half-lives. For radioactive decay chains for which transport is simulated (Section 4.4.2), daughter products enter the groundwater at a rate determined by the half-life of the parent and their own half-life.

Characteristics of the porous media underlying the GSA which must be specified for the mass transport simulations include density and porosity of the media. . Matrix density of the media is a property used by the simulation code PORFLOW to calculate retardation based on the sorption coefficient, or K_d. Porosity (n) is related to matrix density (ρ_s) according to (Freeze and Cherry 1979):

$$n = 1 - \frac{\rho_b}{\rho_s}, \qquad (5.2.1)$$

where ρ_b is bulk density (i.e., oven-dried mass of a matrix sample divided by field volume). A bulk density of approximately 1600 kg/m^3 is reported for the SRS (Looney et al. 1987), although this value can be expected to vary throughout the different formations underlying the SRS. The total porosity of SRS sediments have been found to range from 0.4 to 0.6 (Looney et al. 1987). Assuming a porosity of 0.4, a matrix density of approximately 2670 kg/m^3 can be derived from equation 5.2.1, which is in agreement with the average value of 2650 kg/m^3 provided by Freeze and Cherry (1979) for mineral soils. Thus, this average value of 2650 kg/m^3 was used as a representative value in the PORFLOW simulations.

Although porosities can be expected to vary between sand and clay sediments, sands tend to have lower porosity than clays at the SRS (Looney et al. 1987), and sands dominate the sediment distribution. Diffusional porosity, which is the term found in the advection-dispersion equation for simulating mass transport and is defined as the ratio of the volume of pores *that participate in diffusion* to the total matrix volume, is expected to be somewhat less than the total porosity but slightly greater than effective diffusivity. A modeling study of tritium migration from the Old Burial Ground determined an effective porosity of 0.23 based on calibration efforts (Flach et al. 1996). Therefore, a diffusional porosity of 0.25 was assumed for this analysis.

5.2.2 PORFLOW Transport Simulations

Transport simulations using PORFLOW were accomplished using the simulation grid established for the GSA model (Section 5.1, Figures 5.1-1 and 5.1-2). This allowed utilization of the steady-state flow field computed using the FACT code in the transport simulations. The flow field provided flow velocity and direction from the calibrated model for the GSA. The PORFLOW simulations were carried out with the flow simulation feature disabled; thus further calibration of the flow model was not necessary. Checks of the PORFLOW simulation results were made to ensure that mass balance errors were insignificant.

The source locations identified in Section 4.1 were interpreted in terms of the simulation grid. The source terms, some of which were derived for the Z-Area and E-Area PAs and some of which were developed using the PATHRAE code (Section 4.4.3), are specified in the transport model as releases to the water table, in Ci/yr, as a function of time. Source activities are reported as single curves for each radionuclide at each source, representing all contributions of a particular radionuclide, whether arising from the original inventory or as a daughter product. For example, ^{241}Am is a daughter of ^{241}Pu, but is also present as a parent radionuclide. However, only one source of ^{241}Am at a particular location is specified in the ^{241}Pu chain simulations in PORFLOW; this release includes contributions due to the presence of ^{241}Am in the original inventory, and also due to its buildup from the ^{241}Pu parent in the original inventory. A discussion of the flux to the water table for the radionuclides is presented in Section 4.4.3. The major sources are depicted in Figure 5.2-2.

The grid elements into which the source is placed are actually one element beneath the uppermost element, such that unrealistic diffusion out of the uppermost model boundary is diminished. The number of grid elements with sources does not correspond exactly with the number of sources, because more than one source often fits into the area encompassed by a single grid element.

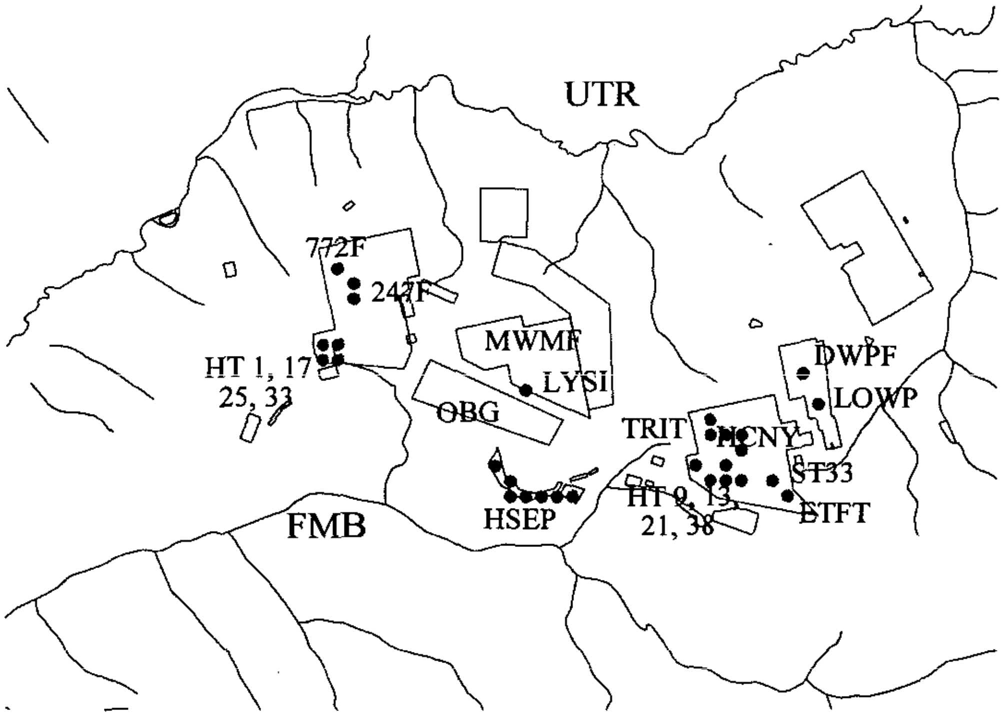

Figure 5.2-2 Location of major contaminant sources

Each simulation was set up for one or more radionuclides, with all sources for each radionuclide activated simultaneously. The simulated plumes of radionuclides are thus a composite of all sources in the GSA area, consistent with requirements of the Composite Analysis. Simulations were carried out for radionuclide source terms for which the sum of peak releases from all sources of the radionuclide were greater than or equal to 10^{-4} Ci/yr within the 1000 year period of assessment. Releases below this criterion lead to calculated doses much less than one mrem/yr summed over all radionuclides; such sources were excluded from the analysis.

Simulations of the radionuclide plumes were carried out for 1000 years, the time of assessment identified previously. Time steps were selected to preserve numerical stability and satisfy mass balance requirements on a grid element-by-grid element basis. Output of the simulations was specified to provide the radionuclide flux (Ci/yr) out of the capture zone encompassing Upper Three Runs and its tributaries (Figure 5.2-2), and the radionuclide flux out of the capture zone encompassing Fourmile Branch and its tributaries. The fluxes are compared with global mass balance checks on the model. This comparison provides assurance that all radionuclide losses from the model domain are accounted for in this analysis.

The results of the transport simulations are shown graphically in Figures 5.2-3 through 5.2-22. These results were used to calculate peak surface water concentrations of each radionuclide (Section 5.3) and exposure and dose (Sections 5.4 and 5.5, respectively) to the maximally-exposed hypothetical individual.

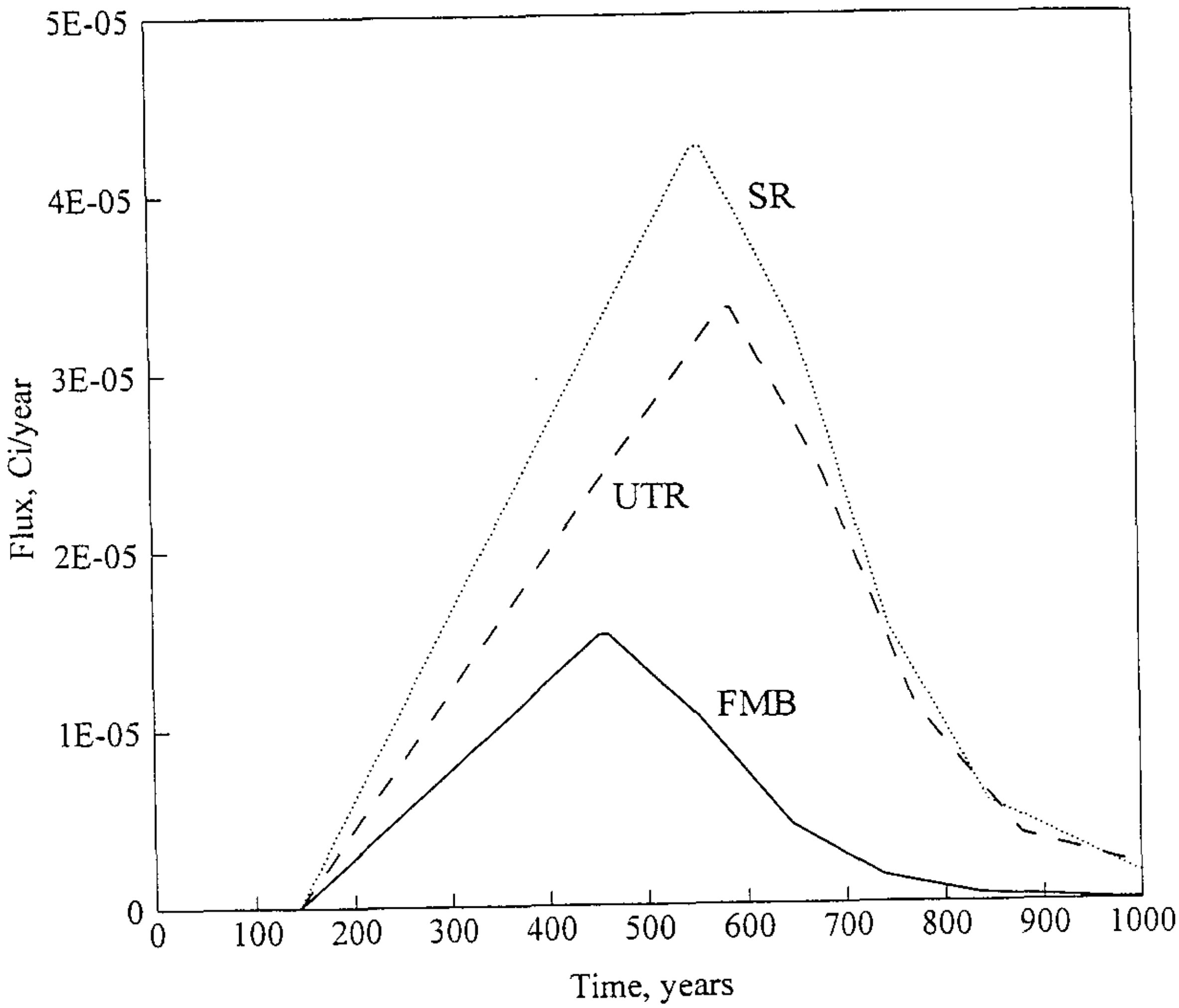

Figure 5.2-3 Predicted ^{227}Ac flux to the creeks

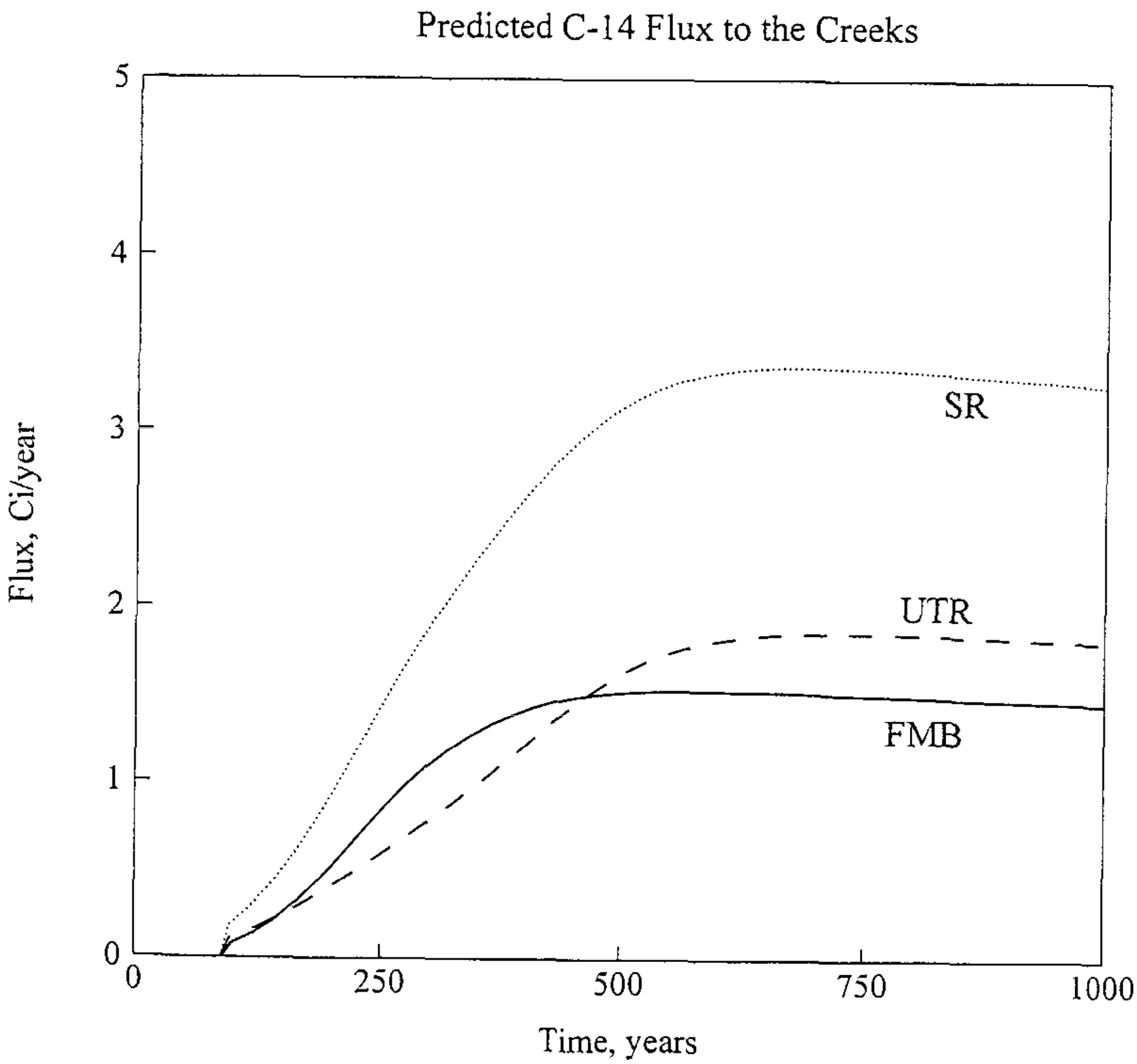

Figure 5.2-4 Predicted ^{14}C flux to the creeks

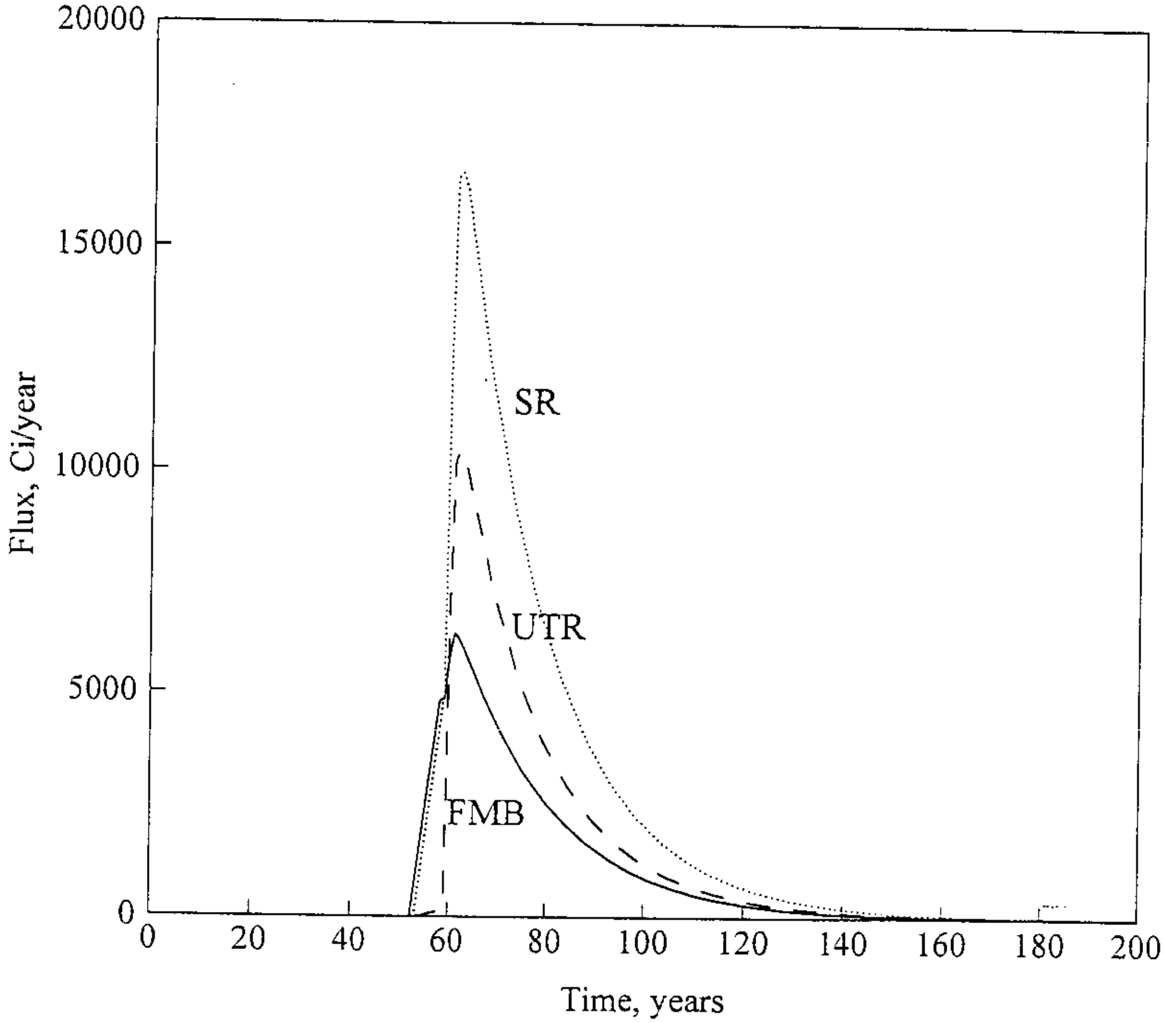

Figure 5.2-5 Predicted ^{3}H flux to the creeks

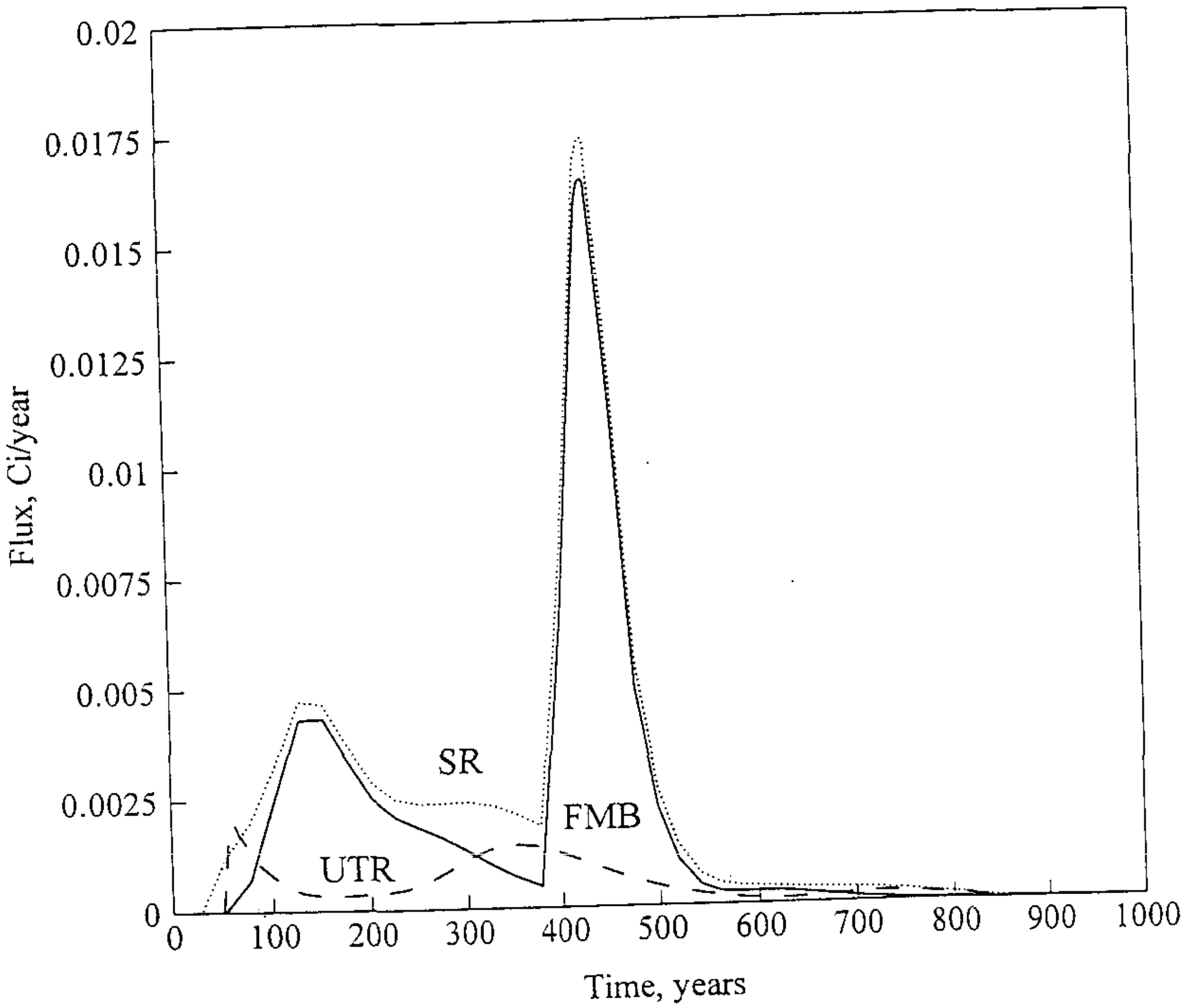

Figure 5.2-6 Predicted ^{129}I flux to the creeks

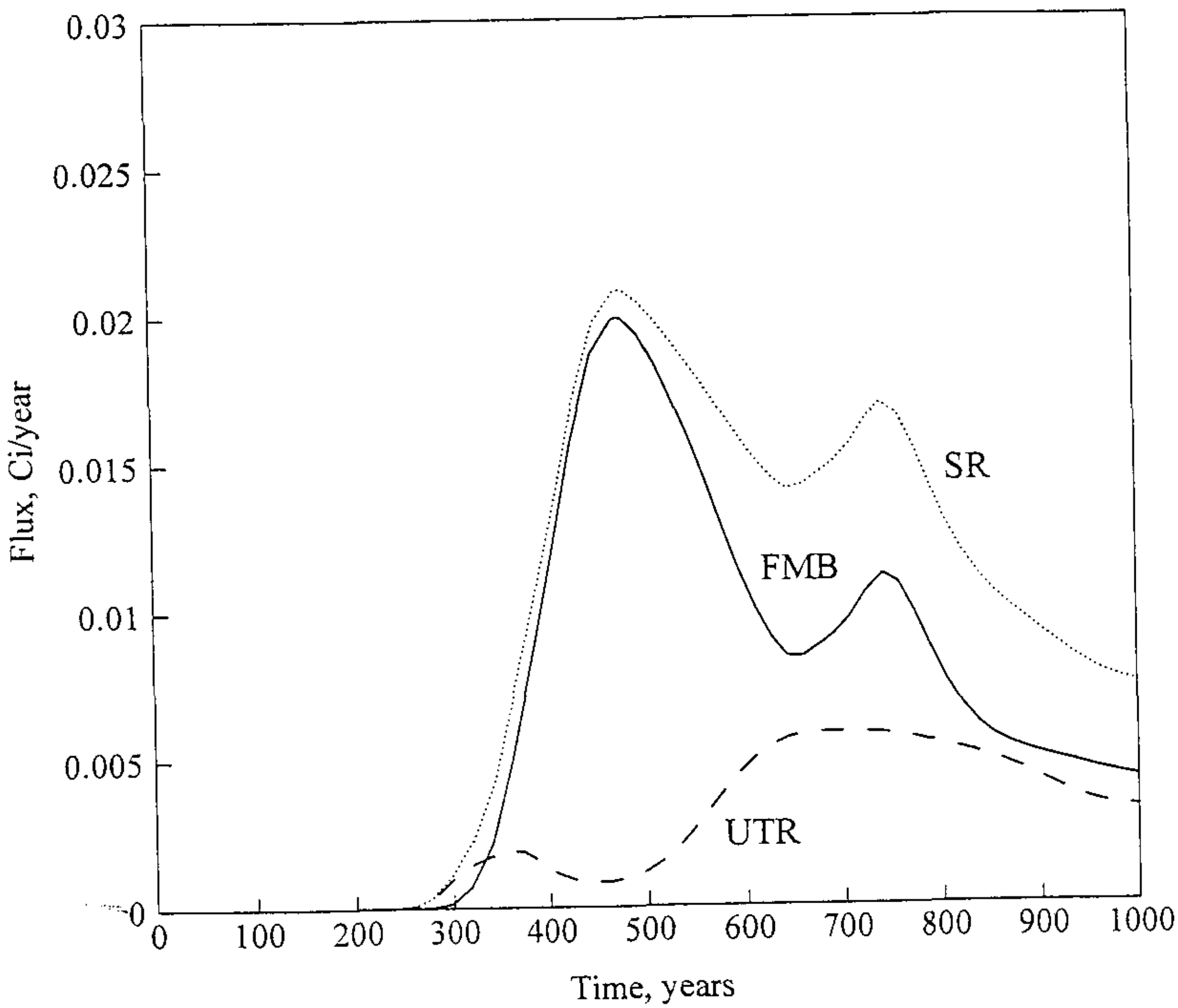

Figure 5.2-7 Predicted ^{237}Np flux to the creeks

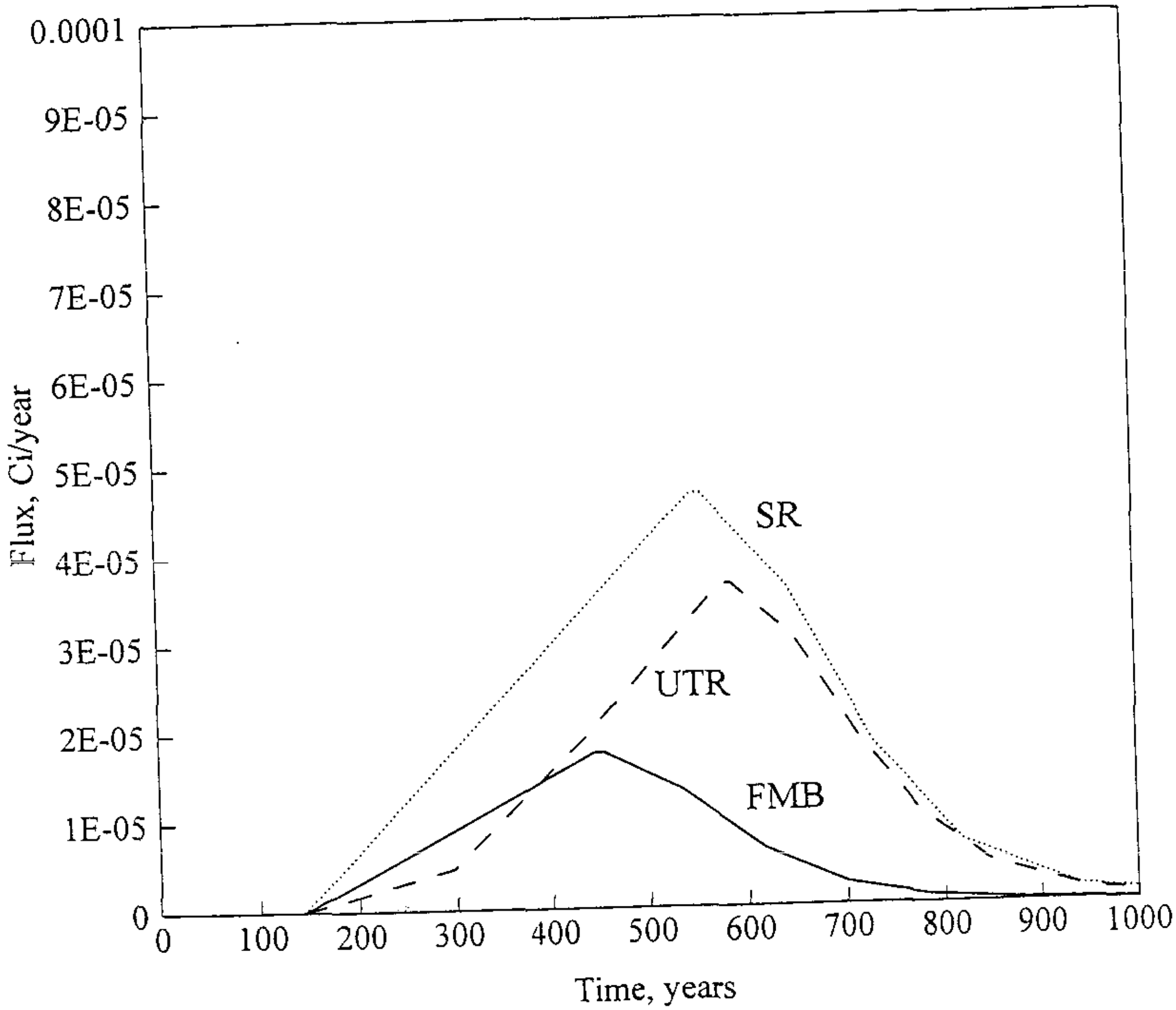

Figure 5.2-8 Predicted ^{231}Pa flux to the creeks

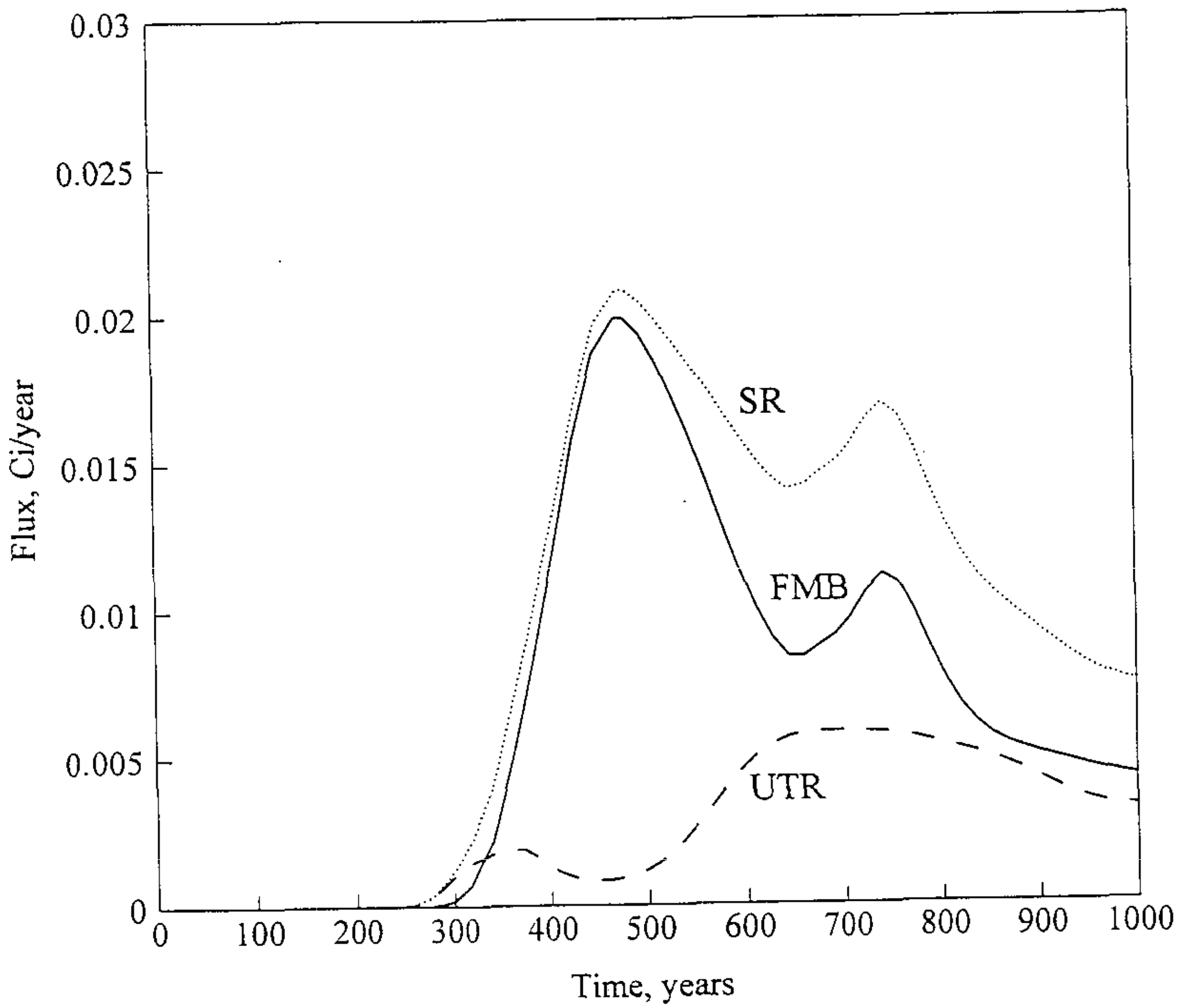

Figure 5.2-9 Predicted ^{233}Pa flux to the creeks

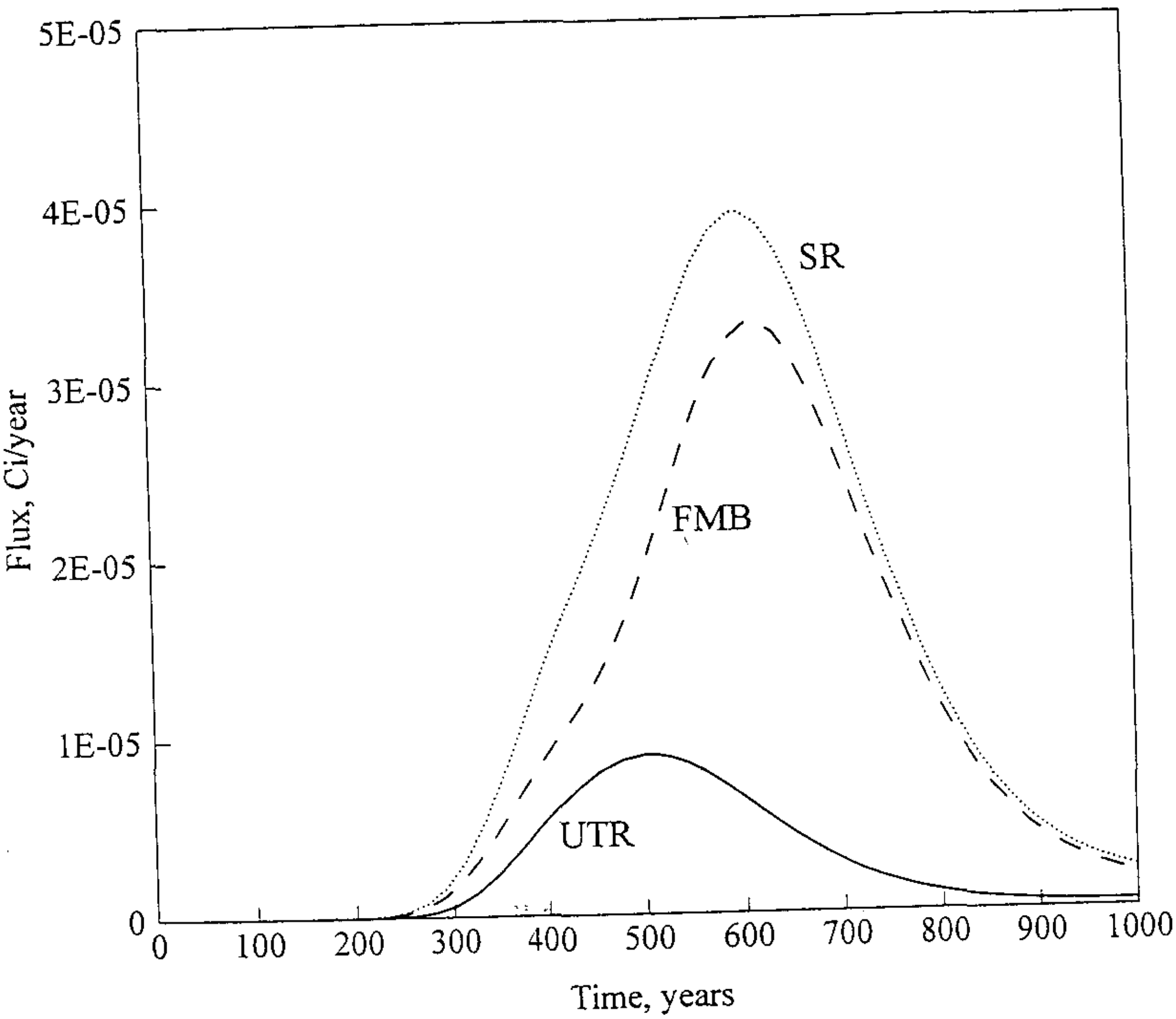

Figure 5.2-10 Predicted ^{210}Pb flux to the creeks

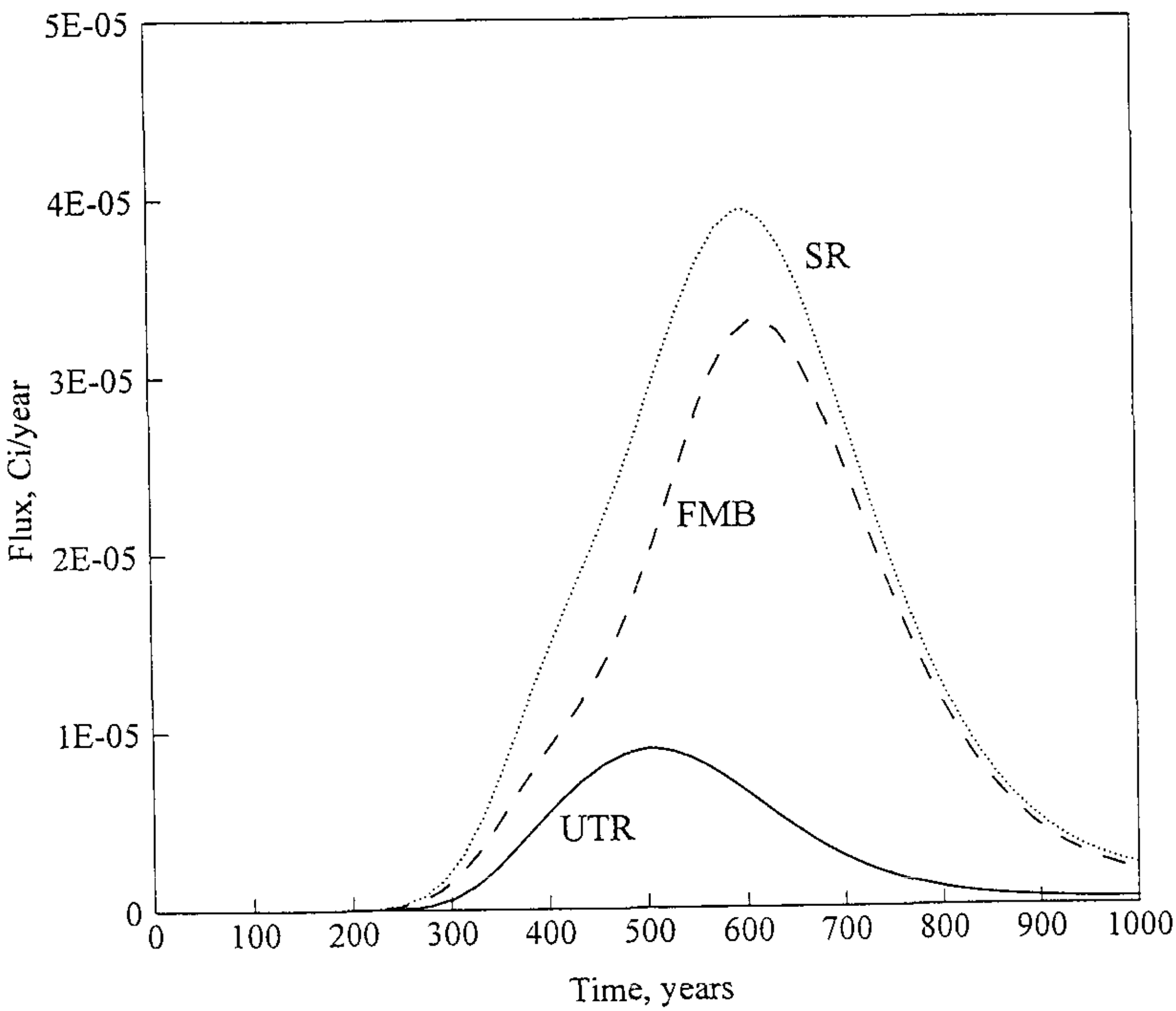

Figure 5.2-11 Predicted ^{210}Po flux to the creeks

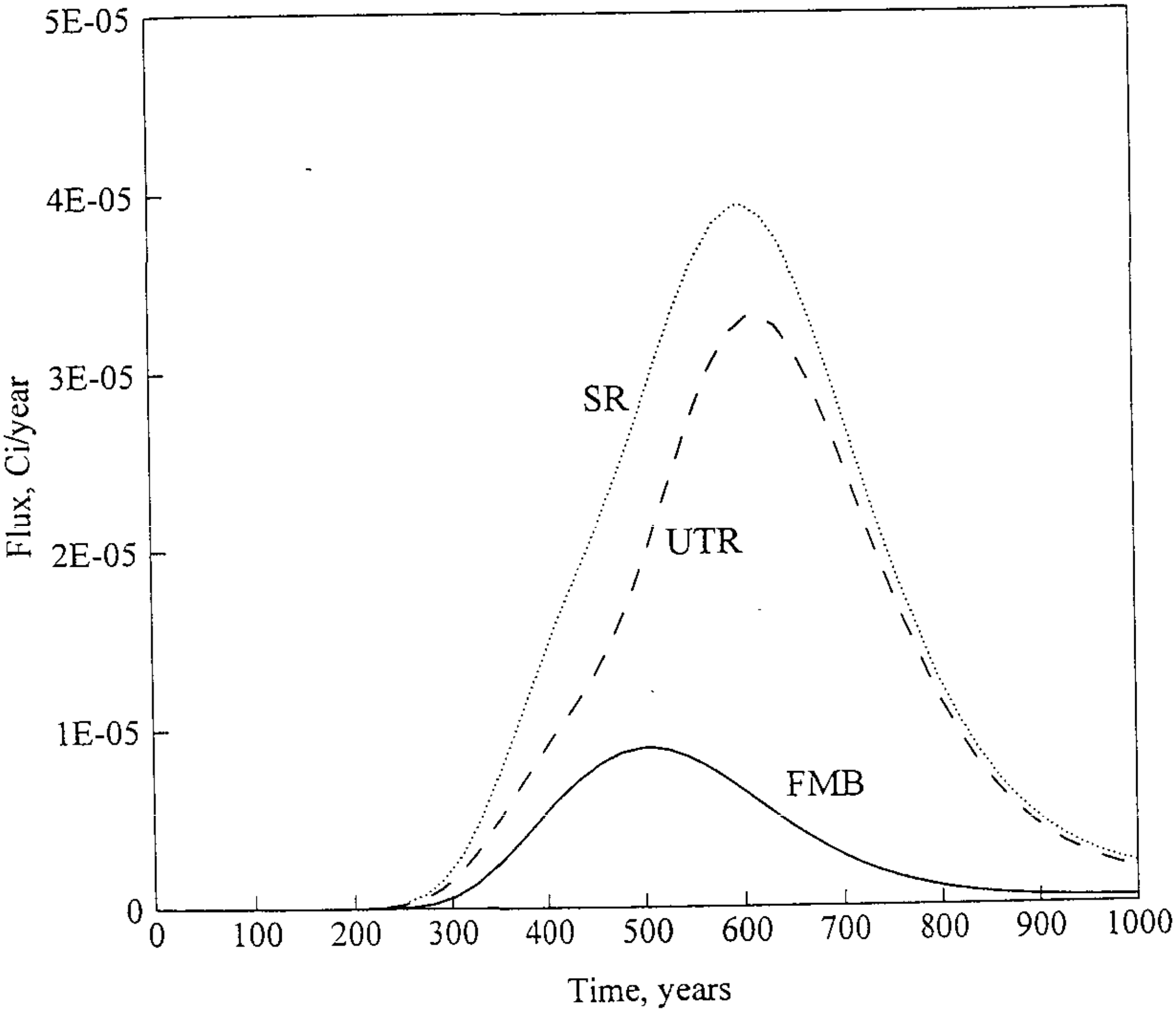

Figure 5.2-12 Predicted ^{226}Ra flux to the creeks

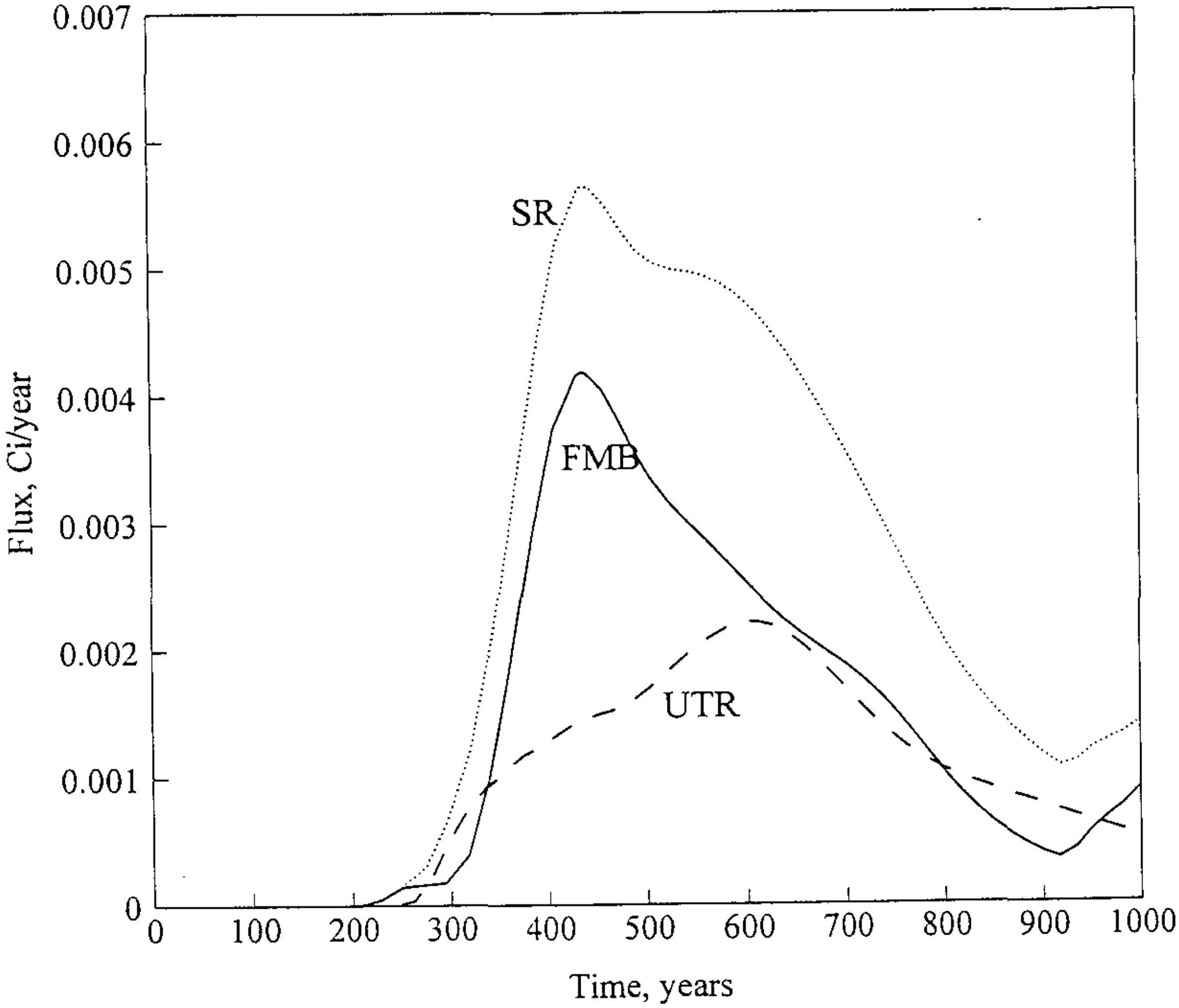

Figure 5.2-13 Predicted ^{79}Se flux to the creeks

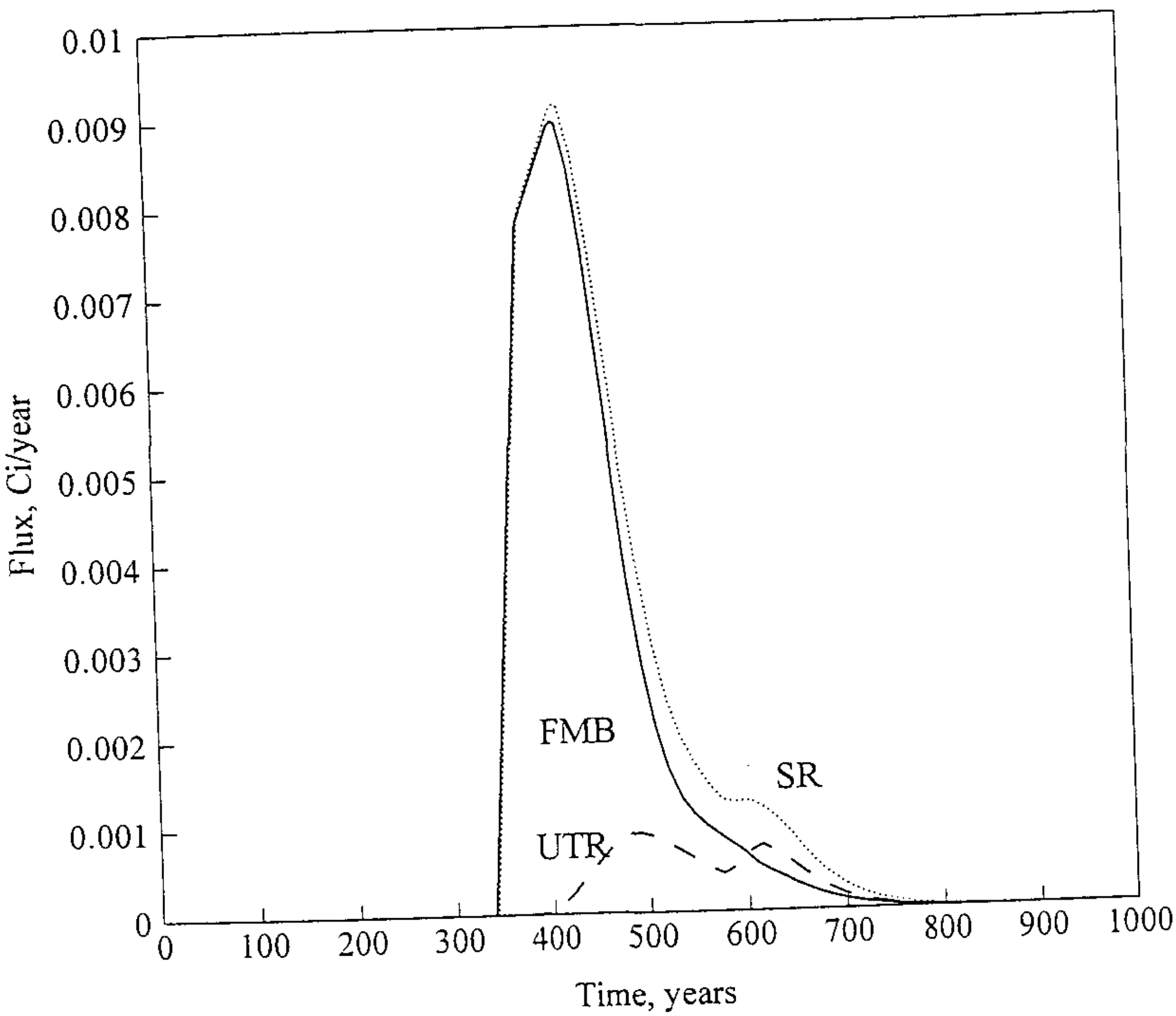

Figure 5.2-14 Predicted ^{90}Sr flux to the creeks

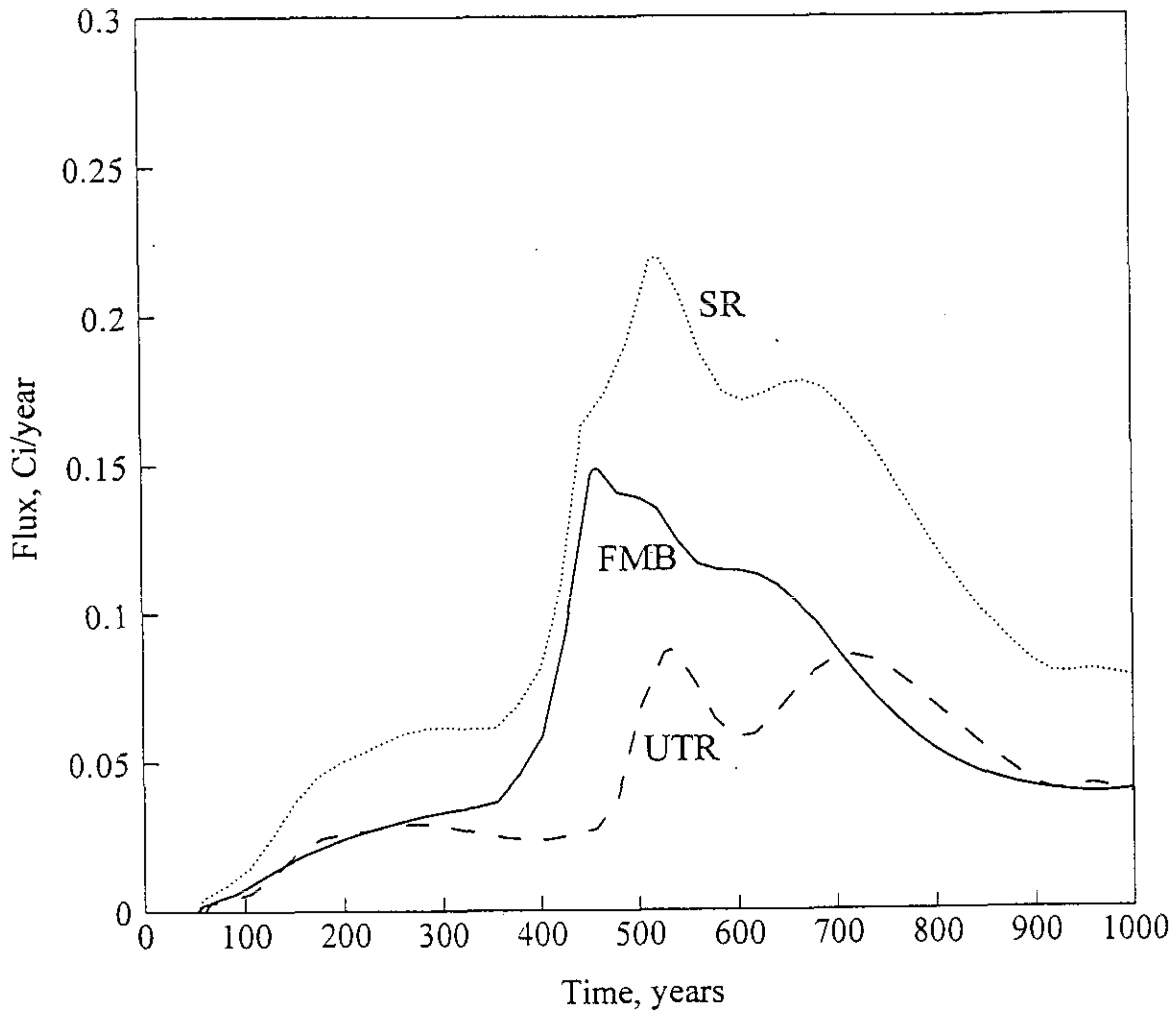

Figure 5.2-15 Predicted ^{99}Tc flux to the creeks

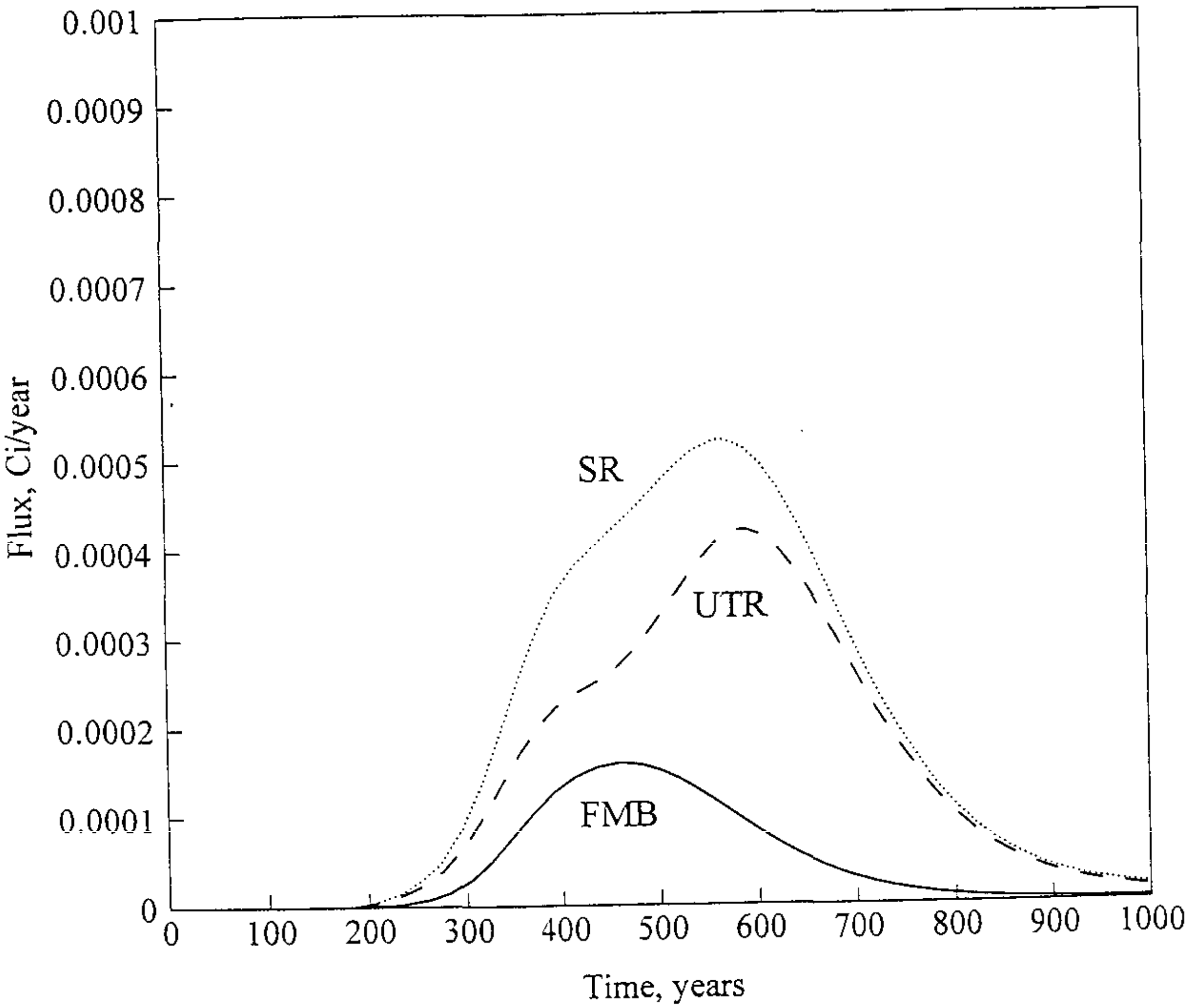

Figure 5.2-16 Predicted ^{230}Th flux to the creeks

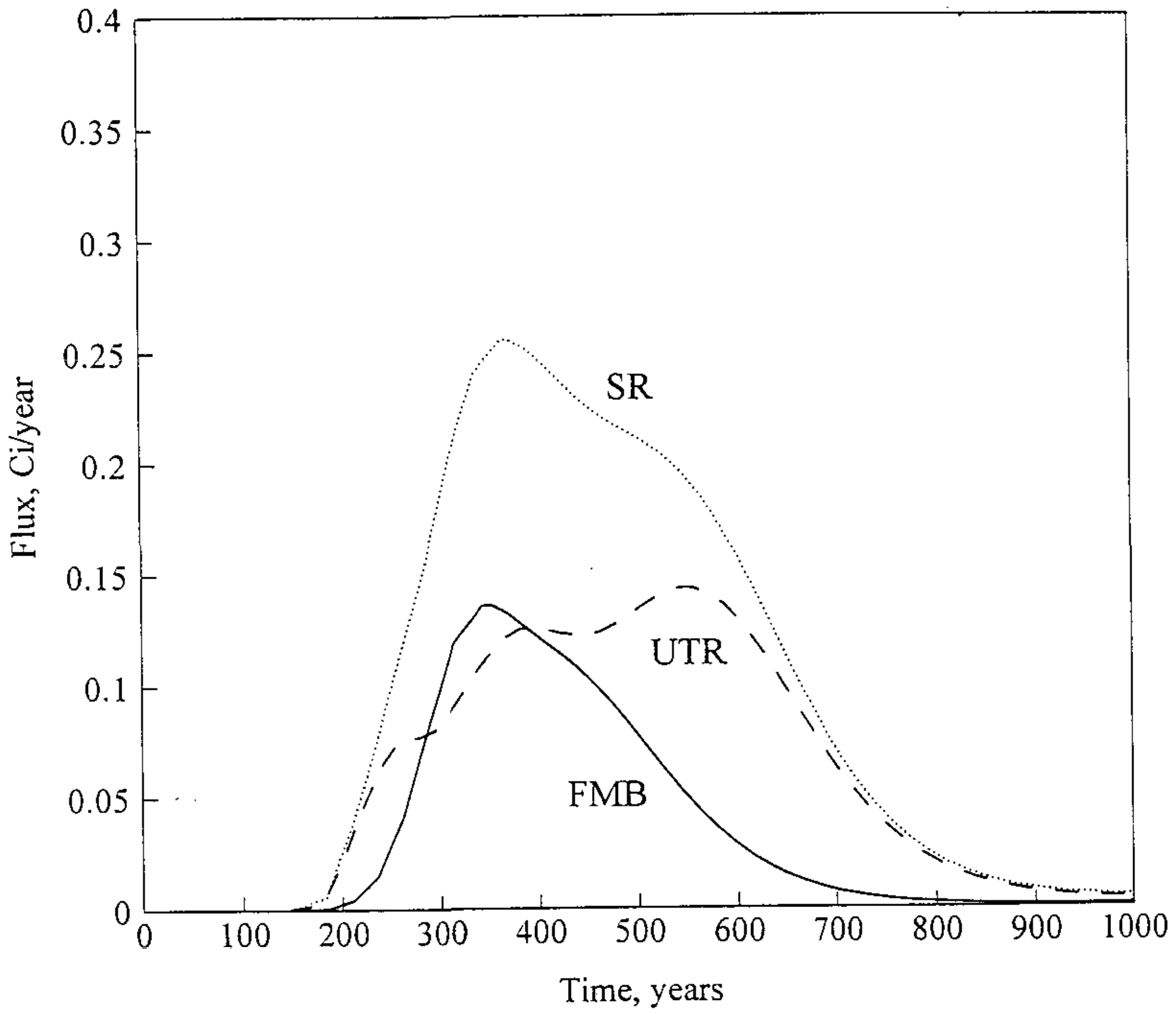

Figure 5.2-17 Predicted ^{234}Th flux to the creeks

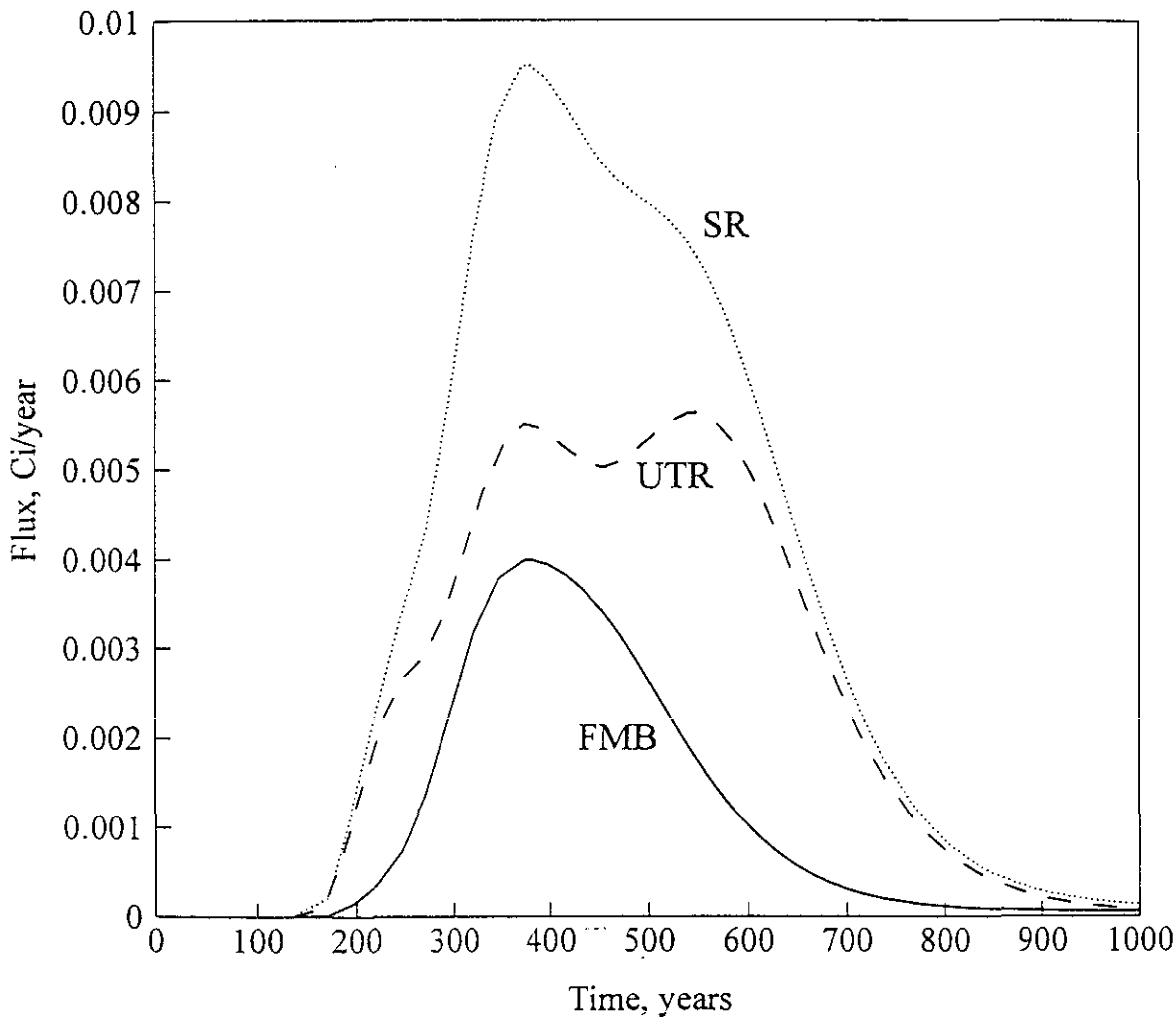

Figure 5.2-18 Predicted ^{233}U flux to the creeks

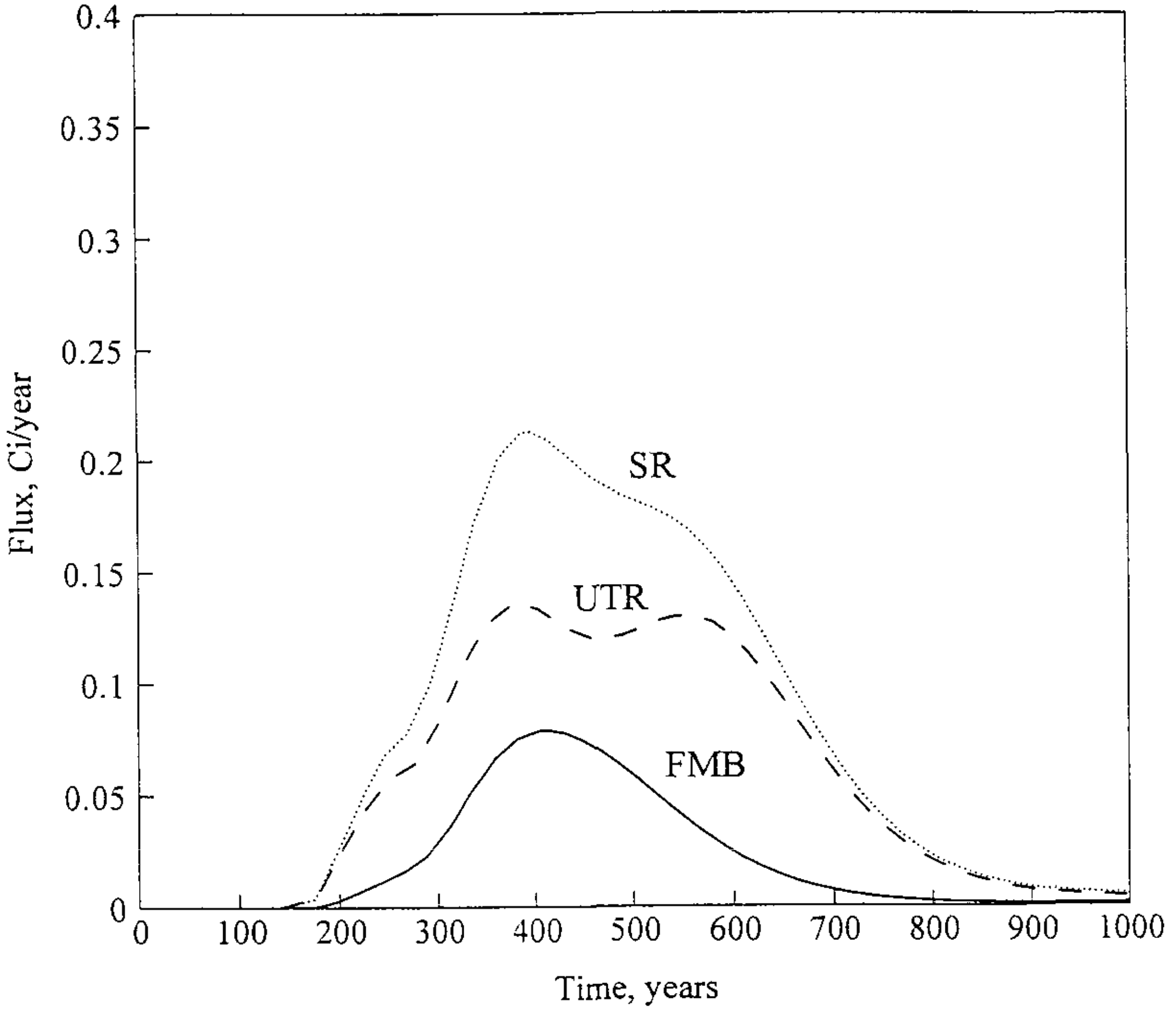

Figure 5.2-19 Predicted ^{234}U flux to the creeks

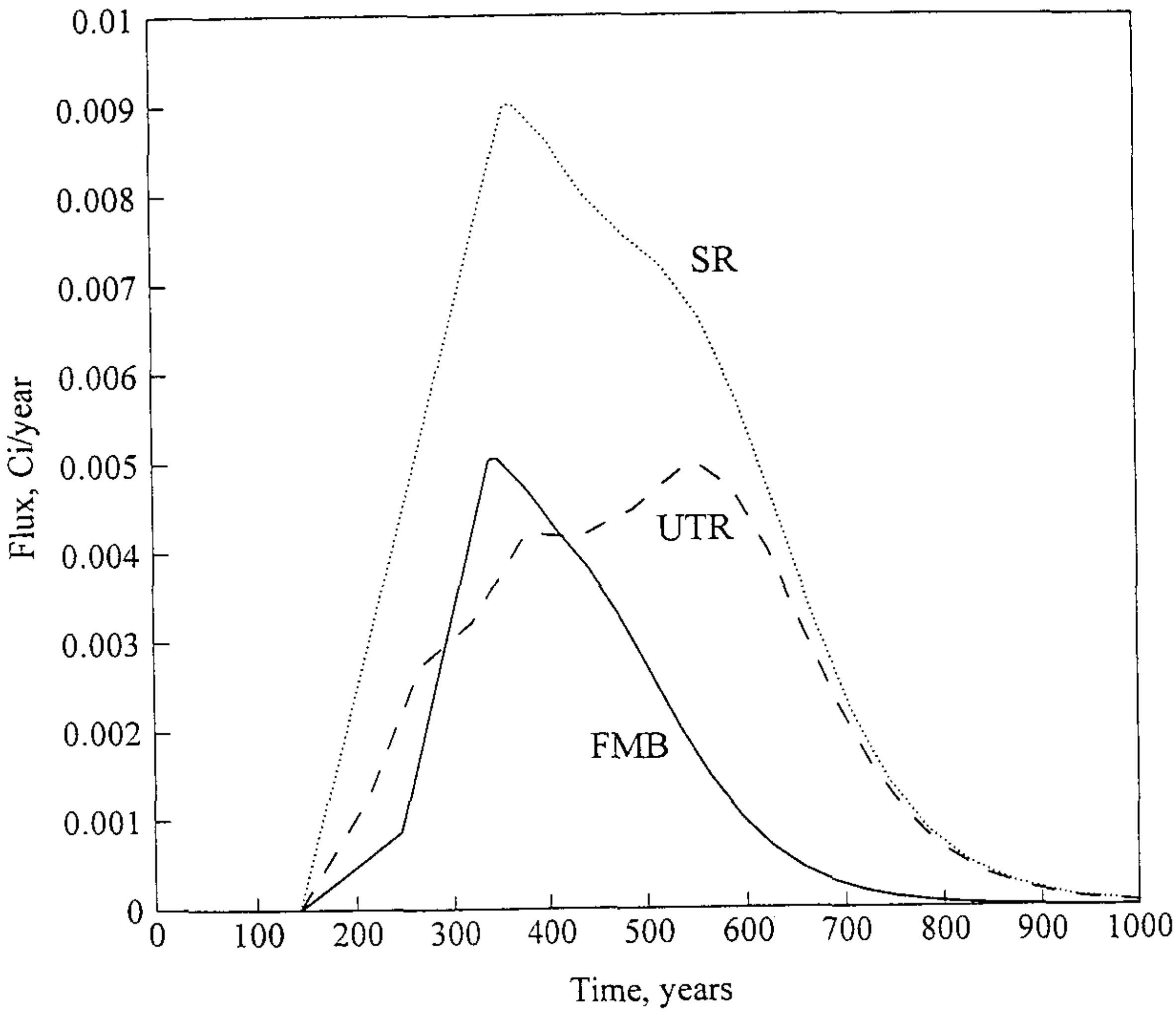

Figure 5.2-20 Predicted ^{235}U flux to the creeks

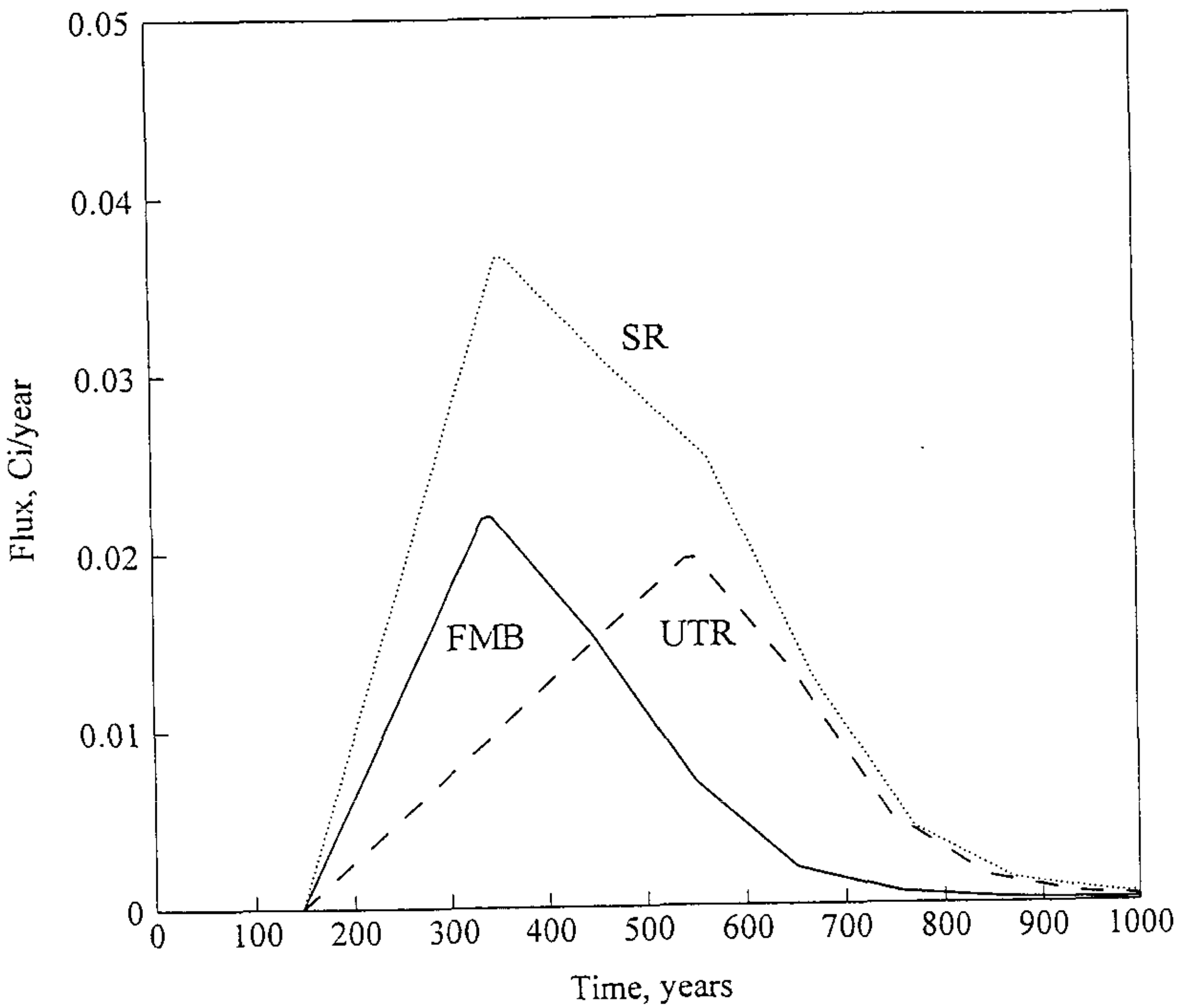

Figure 5.2-21 Predicted ^{236}U flux to the creeks

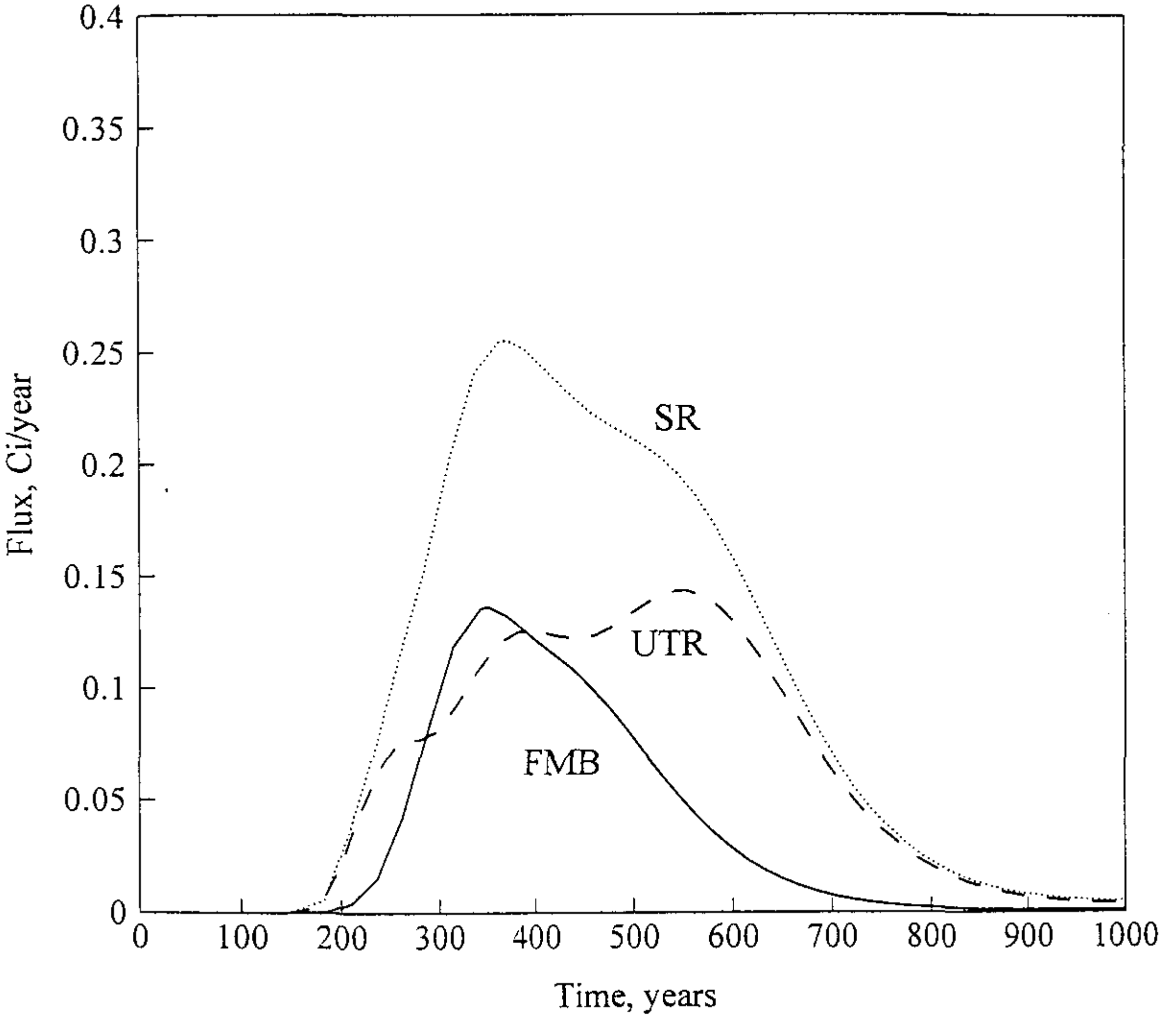

Figure 5.2-22 Predicted ^{238}U flux to the creeks

5.3 Surface Water Concentrations

Concentrations of radionuclides potentially released from subsurface sources in the GSA were calculated using the LADTAP (Liquid Annual Doses To All Persons) XL spreadsheet model (Hamby 1991a). This spreadsheet, which essentially implements the LADTAP II (Strenge et al. 1986) model based on the U. S. Nuclear Regulatory Commission Regulatory Guide 1.109 (NRC 1977), with some improvements. The model utilizes both default and site-specific data in calculating radionuclide concentrations in surface water, and resulting internal and external radiological doses to individuals and populations.

In order to calculate surface water concentrations of radionuclides, annual flux of radionuclides (Ci/yr) to the surface water body must be specified, as well as flow rates of the water body. Average concentrations at specified downstream locations are calculated. These concentrations do not account for radionuclide decay during transit from the point of discharge from groundwater, as this decay is accounted for in the exposure and dose calculations (Section 5.4).

Fluxes of radionuclides to Upper Three Runs and Fourmile Branch were obtained from the contaminant transport modeling described in Section 5.2. As described in that section, the total annual flux of each radionuclide out of the model domain was apportioned to Upper Three Runs and Fourmile Branch according to an analysis of the capture zone of each surface water body and its tributaries. This provided assurance that all radionuclides were accounted for in either the Upper Three Runs or Fourmile Branch water concentrations. Calculated peak fluxes are given in Table 5.3-1.

Table 5.3-1 Estimated Peak Radionuclide Fluxes to Surface Water

Radionuclide	Daughters	Upper Three Runs Creek		Fourmile Branch		Savannah River	
		Peak Flux (Ci/yr)	Time of Peak Flux (yr)	Peak Flux (Ci/yr)	Time of Peak Flux (yr)	Peak Flux (Ci/yr)	Time of Peak Flux (yr)
^{241}Am		a		a		a	
	^{237}Np	b		b		b	
^{243}Am		a		a		a	
	^{239}Np	a		a		a	
	^{239}Pu	b		b		b	
^{14}C		1.86	728	1.53	592	3.37	692
^{244}Cm		a		a		a	
	^{240}Pu	b		b		b	
	^{236}U	b		b		b	
^{246}Cm		a		a		a	
^{55}Fe		a		a		a	
^{3}H		1.05×10^{4}	62	6.34×10^{3}	61	1.67×10^{4}	62
^{129}I		1.98×10^{-3}	62	1.64×10^{-2}	434	1.74×10^{-2}	432
^{40}K		a		a		a	
^{93}Mo		a		a		a	
	^{93m}Nb	a		a		a	
^{93m}Nb		a		a		a	
^{94}Nb		a		a		a	
^{59}Ni		a		a		a	
^{237}Np		5.83×10^{-3}	685	1.99×10^{-2}	476	2.09×10^{-2}	478
	^{233}Pa	5.83×10^{-3}	685	1.99×10^{-2}	476	2.09×10^{-2}	478
	^{233}U	b		b		b	

Radionuclide	Daughters	Upper Three Runs Creek Peak Flux (Ci/yr)	Upper Three Runs Creek Time of Peak Flux (yr)	Fourmile Branch Peak Flux (Ci/yr)	Fourmile Branch Time of Peak Flux (yr)	Savannah River Peak Flux (Ci/yr)	Savannah River Time of Peak Flux (yr)
^{238}Pu		a		a		a	
	^{234}U	b		b		b	
	^{230}Th	b		b		b	
	^{226}Ra	b		b		b	
	^{210}Pb	b		b		b	
	^{210}Po	b		b		b	
^{239}Pu		a		a		a	
	^{235}U	b		b		b	
^{240}Pu		a		a		a	
	^{236}U	b		b		b	
^{241}Pu		a		a		a	
	^{241}Am	2.45×10^{-16}	1020	2.51×10^{-15}	1010	2.76×10^{-15}	1020
	^{237}Np	b		b		b	
^{242}Pu		a		a		a	
^{226}Ra		a		a		a	
	^{210}Pb	a		a		a	
	^{210}Po	a		a		a	
^{79}Se		2.22×10^{-3}	608	4.18×10^{-3}	436	5.65×10^{-3}	440
^{126}Sn		a		a		a	
^{90}Sr		8.94×10^{-4}	488	8.93×10^{-3}	416	9.13×10^{-3}	420
^{99}Tc		8.73×10^{-2}	533	1.49×10^{-1}	458	2.20×10^{-1}	520
^{232}Th		a		a		a	
^{233}U		5.63×10^{-3}	545	4.00×10^{-3}	378	9.50×10^{-3}	378

Radionuclide	Daughters	Upper Three Runs Creek Peak Flux (Ci/yr)	Upper Three Runs Creek Time of Peak Flux (yr)	Fourmile Branch Peak Flux (Ci/yr)	Fourmile Branch Time of Peak Flux (yr)	Savannah River Peak Flux (Ci/yr)	Savannah River Time of Peak Flux (yr)
^{234}U		1.36×10^{-1}	383	7.89×10^{-2}	411	2.13×10^{-1}	395
	^{230}Th	4.20×10^{-4}	587	1.59×10^{-4}	465	5.21×10^{-4}	565
	^{226}Ra	3.31×10^{-5}	615	8.93×10^{-6}	505	3.92×10^{-5}	601
	^{210}Pb	3.31×10^{-5}	615	8.93×10^{-6}	505	3.92×10^{-5}	601
	^{210}Po	3.31×10^{-5}	615	8.93×10^{-6}	505	3.92×10^{-5}	601
^{235}U		4.99×10^{-3}	548	5.06×10^{-3}	344	9.01×10^{-3}	362
	^{231}Pa	3.64×10^{-5}	582	1.75×10^{-5}	452	4.66×10^{-5}	554
	^{227}Ac	3.35×10^{-5}	584	1.52×10^{-5}	460	4.26×10^{-5}	556
^{236}U		1.96×10^{-2}	549	2.20×10^{-2}	340	3.66×10^{-2}	356
^{238}U		1.44×10^{-1}	551	1.36×10^{-1}	348	2.55×10^{-1}	370
	^{234}Th	1.44×10^{-1}	551	1.36×10^{-1}	348	2.55×10^{-1}	370
	^{234}U	b		b		b	
^{93}Zr		a		a		a	
	^{93m}Nb	a		a		a	

a - Radionuclide was screened from further consideration according to analysis in Section 4.2.

b - Flux of radioactive daughter was added to flux of same radionuclide initially present in source.

Surface water flow rates for Upper Three Runs, Fourmile Branch, and the Savannah River were estimated from stream gauging data collected by the U. S. Geological Survey (USGS 1997). For both on-site streams, flow data utilized were collected from regions in close proximity to their confluence with the Savannah River. According to the USGS data, the flow of Upper Three Runs near the point of confluence with the Savannah River averages approximately 6.1 m^3/s (217 cfs). The flow of Fourmile Branch near the point of confluence with the Savannah River averages approximately 0.68 m^3/s (24 cfs). The flow rate of the Savannah River, at a location approximately 20 km downstream of the site (where Highway 301 crosses the river) which is potentially affected by discharges to both SRS streams, is approximately 300 m^3/s (10,500 cfs) on average.

Calculated peak radionuclide concentrations in surface water are given in Table 5.3-2. These concentrations are calculated in the LADTAP XL spreadsheet by dividing the peak flux of each radionuclide to each stream by the flow rates given above.

5.4 Exposure Scenarios

The points of exposure and dose assessment for this Composite Analysis were defined in Section 2.4, Dose Objectives. Points of assessment at the mouths of UTR and FMB and on the Savannah River were selected to correspond with the plans for future use of the SRS. The Locations on Upper Three Runs and on Fourmile Branch, just downstream of the points at which radionuclides may enter these streams as a result of discharge of contaminated groundwater from the GSA, were selected as conservative points of assessment to facilitate sensitivity analysis with respect to future land use. The purpose of this section is to define the exposure scenarios that are assumed in calculating doses at these points of assessment.

Table 5.3-2 Calculated Peak Radionuclide Concentration in Surface Water

Radionuclide	Daughters	Upper Three Runs Creek Peak Concentration (Ci/m^3)	Fourmile Branch Peak Concentration (Ci/m^3)	Savannah River Peak Concentration (Ci/m^3)
^{241}Am		a	a	a
	^{237}Np	b	b	b
^{243}Am		a	a	a
	^{239}Np	a	a	a
	^{239}Pu	b	b	b
^{14}C		9.60×10^{-9}	7.12×10^{-8}	3.60×10^{-10}
^{244}Cm		a	a	a
	^{240}Pu	b	b	b
	^{236}U	b	b	b
^{246}Cm		a	a	a
^{55}Fe		a	a	a
^{3}H		6.88×10^{-5}	5.92×10^{-4}	3.73×10^{-6}
^{129}I		1.30×10^{-11}	1.53×10^{-9}	3.89×10^{-12}
^{40}K		a	a	a
^{93}Mo		a	a	a
	^{93m}Nb	a	a	a
^{93m}Nb		a	a	a
^{94}Nb		a	a	a
^{59}Ni		a	a	a
^{237}Np		3.84×10^{-11}	1.86×10^{-9}	4.67×10^{-12}
	^{233}Pa	3.84×10^{-11}	1.86×10^{-9}	4.67×10^{-12}
	^{233}U	b	b	b

Radionuclide	Daughters	Upper Three Runs Creek Peak Concentration (Ci/m^3)	Fourmile Branch Peak Concentration (Ci/m^3)	Savannah River Peak Concentration (Ci/m^3)
^{238}Pu		a	a	a
	^{234}U	b	b	b
	^{230}Th	b	b	b
	^{226}Ra	b	b	b
	^{210}Pb	b	b	b
	^{210}Po	b	b	b
^{239}Pu		a	a	a
	^{235}U	b	b	b
^{240}Pu		a	a	a
	^{236}U	b	b	b
^{241}Pu		a	a	a
	^{241}Am	1.61×10^{-24}	2.34×10^{-22}	6.17×10^{-25}
	^{237}Np	b	b	b
^{242}Pu		a	a	a
^{226}Ra		a	a	a
	^{210}Pb	a	a	a
	^{210}Po	a	a	a
^{79}Se		1.46×10^{-11}	3.90×10^{-10}	1.27×10^{-12}
^{126}Sn		a	a	a
^{90}Sr		5.89×10^{-12}	8.34×10^{-10}	2.04×10^{-12}
^{99}Tc		5.75×10^{-10}	1.39×10^{-8}	4.92×10^{-11}
^{232}Th		a	a	a
^{233}U		3.71×10^{-11}	3.73×10^{-10}	2.13×10^{-12}

Radionuclide	Daughters	Upper Three Runs Creek Peak Concentration (Ci/m³)	Fourmile Branch Peak Concentration (Ci/m³)	Savannah River Peak Concentration (Ci/m³)
^{234}U		8.96×10^{-10}	7.36×10^{-9}	4.77×10^{-11}
	^{230}Th	2.77×10^{-12}	1.49×10^{-11}	1.17×10^{-13}
	^{226}Ra	2.18×10^{-13}	8.34×10^{-13}	8.79×10^{-15}
	^{210}Pb	2.18×10^{-13}	8.34×10^{-13}	8.79×10^{-15}
	^{210}Po	2.18×10^{-13}	8.34×10^{-13}	8.79×10^{-15}
^{235}U		3.28×10^{-11}	4.72×10^{-10}	2.02×10^{-12}
	^{231}Pa	2.39×10^{-13}	1.63×10^{-12}	1.04×10^{-14}
	^{227}Ac	2.21×10^{-13}	1.42×10^{-12}	9.54×10^{-15}
^{236}U		1.29×10^{-10}	2.06×10^{-9}	8.20×10^{-12}
^{238}U		9.45×10^{-10}	1.27×10^{-8}	5.72×10^{-11}
	^{234}Th	9.45×10^{-10}	1.27×10^{-8}	5.72×10^{-11}
	^{234}U	b	b	b
^{93}Zr		a	a	a
	^{93m}Nb	a	a	a

a - Radionuclide was screened from further consideration according to analysis in Sections 4.2 and 4.4.2.

b - Flux of radioactive daughter was added to flux of same radionuclide initially present in source.

In Section 4.3, the pathways to a human receptor from a subsurface source of radionuclides were reviewed. As part of this review, pathways were considered to be either dominant or insignificant. Those considered dominant are related to contamination of surface water (see Figure 4.3-1), and include: 1) external exposure to creek sediment, contaminated by deposition of radionuclides in surface water; 2) ingestion of, and physical contact with, contaminated surface water; and 3) ingestion of aquatic biota exposed to contaminated surface water.

Scenarios which consider exposure associated with contaminated surface water were derived from the LADTAP XL spreadsheet version (Hamby 1991a) of the LADTAP generation of dose assessment codes. The LADTAP codes were originally developed by the Nuclear Regulatory Commission to implement Regulatory Guide 1.109 (NRC 1977) for surface water exposure and dose models. The LADTAP XL spreadsheet is a SRS-site specific version of the LADTAP II model, since various site-specific factors have been incorporated into the spreadsheet in the place of some of the more generic factors. The exposure scenarios addressed in the LADTAP XL spreadsheet model are those associated with: 1) surface water ingestion; 2) ingestion of aquatic foods; 3) direct exposure during shoreline activities; and 4) swimming and boating. The LADTAP XL spreadsheet allows calculation of both maximum individual doses and population doses.

Exposure via ingestion of surface water is assumed to occur as a result of ingestion of surface water by a hypothetical individual. For the hypothetical maximally exposed individual this rate is 730 L/yr, and for the average individual in the population, the rate is 370 L/yr. These water intake rates are consistent with rates suggested in the NRC Regulatory Guide 1.109. The equation describing radionuclide intake from ingestion of river water is

$$I_i^{W} = U_{W} t^{I} C_i e^{-\lambda_i t_W}, \tag{5.4.1}$$

where,

I_i^W = individual exposure to radionuclide i from drinking water pathway (µCi),

U_W = water consumption rate (L/yr),

t^I = intake duration (1 yr),

C_i = concentration of radionuclide I in river water (µCi/L),

λ_i = radioactive decay constant for radionuclide I, (d^{-1}), and

t_w = transit time between release and consumption (d).

Reduction of radionuclide concentrations as a result of sorption on sediment surfaces and subsequent deposition, or as a result of water treatment, are not accounted for in the LADTAP XL model. Reduction due to radioactive decay during transit time (t_w) between discharge of radionuclides to the streams and consumption of the water is accounted for, based on an assumed average transit time of 1.5 days.

Aquatic foods of potential importance to calculating dose are fish and invertebrates. Exposure to radionuclides from ingestion of fish and invertebrates obtained from river water contaminated with radionuclide i, at concentration C_i, is evaluated from:

$$I_i^F = U_F t^I C_i B_i e^{-\lambda_i t_f}, \tag{5.4.2}$$

where,

I_i^F = intake of radionuclide i from aquatic foods pathway (µCi),

U_F = aquatic food consumption rate (kg/yr),

B_i = bioaccumulation factor (L/kg), and

t_f = transport time between harvest and consumption (d).

Radionuclide-specific bioaccumulation factors for these food sources are those provided in the NRC Regulatory Guide 1.109 for the radionuclides addressed in the Composite Analysis. Aquatic food consumption rates are assumed to be a maximum of 19 kg/yr for a hypothetical individual, and 9 kg/yr for the average member of the population (Hamby 1991a). Average time between harvest and consumption of fish and invertebrates is assumed to be 2 days, during which radioactive decay may occur.

Exposure to contaminated shoreline sediments is addressed in the LADTAP XL spreadsheet model using the NRC Regulatory Guide 1.109 equations for this pathway. A factor describing deposition of radionuclides on sediment was derived from empirical data obtained from the Columbia River. A shore-width factor of 0.2 (NRC 1977), also derived from experimental data, is used to represent the fraction of exposure to an infinite plane source estimated for shoreline exposures. Unlike the Regulatory Guide 1.109, which assumes a buildup time of 15 years, the LADTAP XL spreadsheet assumes the shoreline sediments have been exposed to the calculated radionuclide concentrations for 40 years (t_b), corresponding to the approximate operating period of SRS facilities. Exposure to radionuclide i via the shoreline activities pathway is described by:

$$E_i^{SH} = 100 U_{SH}\, 0.2 C_i \tau_i (1 - e^{-\lambda_i t_b}), \tag{5.4.3}$$

where,

E_i^{SH} = individual exposure to radionuclide i from shoreline activities pathway (μCi-yr/m^2),

100 = water-to-sediment transfer coefficient (L/m^2-d)

U_{SH} = time exposed to shoreline annually (yr),

0.2 = shore width factor (unitless),

τ_i = radiological half-life of radionuclide i (d), and

t_b = time sediment is exposed to contaminated water (yr).

The time of shoreline exposure (U_{SH}) is assumed to be 23 hours (2.6×10^{-3} yr) during a year for hypothetical members of the public, and 110 person-yr for populations, based on a study of water usage in the vicinity of the SRS (Hamby 1991b).

In the LADTAP XL spreadsheet, the hypothetical individuals and populations are assumed to participate in swimming and boating activities for periods of time (t_s) consistent with those reported by Hamby (1991b). The time spent by a hypothetical individual swimming and boating is assumed to be 1.0×10^{-3} yr (8.9 hr) and 2.4×10^{-3} yr (21 hr), respectively. The population is assumed to spend 18 person-yr swimming and 126 person-yr boating. The external exposure received is estimated from:

$$E_i^S = G t_s C_i^{m3}, \quad (5.4.4)$$

where,

E_i^S = individual external exposure to radionuclide i from boating and swimming pathway (μCi-yr/m³),

G = geometry factor (1 for swimming; 0.5 for boating),

t_s = time spent swimming or boating (yr), and

C_i^{m3} = concentration of radionuclide i in river water (μCi/m³).

Complete submersion assumed for swimming gives a geometry factor of 1; for boating, the individual is assumed to remain on the surface of the water, represented by a geometry factor of 0.5.

Immersion in water contaminated with ^3H can lead to a dose via skin absorption. Intake of ^3H via this exposure route is estimated in LADTAP XL from:

(5.4.5)

$$I_T^{skin} = t_s C_T I_W^{skin},$$

where,

I_T^{skin}	=	intake of ^3H through skin absorption,
C_T	=	concentration of ^3H in river water (μCi/ml), and
I_W^{skin}	=	water absorption rate for total body submersion (35 ml/hr).

The water absorption rate of 35 ml/hr is based on empirical data (Hamby 1991a).

River water concentrations used in the equations described above were presented in Section 5.3. These exposure models were utilized in calculating doses to maximally-exposed hypothetical individuals (Section 5.5) and to hypothetical populations (Section 7.4).

5.5 Dose Calculations

Discharge of radionuclides in groundwater beneath the GSA may lead to human exposure and dose. Potentially important pathways leading to dose were identified in Section 4.3. These pathways include those associated with contamination of surface water. Surface water concentrations (Section 5.3) and exposure scenarios (Section 5.4) were evaluated using the calculated fluxes of radionuclides to streams (Section 5.2) and the LADTAP XL spreadsheet, from which all-pathway doses were calculated. Estimated doses to human receptors at the points of assessment identified in Section 2.4 are described in this section.

5.5.1 Equations for Dose Calculations

Doses calculated using the LADTAP XL spreadsheet utilize the equations described in Section 5.4 to evaluate the exposure of hypothetical individuals to radionuclides potentially discharged to Upper Three Runs and Fourmile Branch, in the vicinity of the GSA. The annual dose from ingestion of water, D_i^W(mrem), is calculated from:

$$D_i^W = I_i^W DF_i^I , \tag{5.5.1}$$

where I_i^W is the annual intake of radionuclide i (μCi) from ingestion of water (see Equation 5.4.1), and DF_i^I is the internal dose factor (mrem/μCi). Internal dose factors used by the LADTAP XL model are from DOE/EH-0071 (USDOE 1988b), with some modifications allowing for daughter ingrowth (Hamby 1991).

Annual dose from ingestion of aquatic foods, D_i^F (mrem), is calculated from:

$$D_i^F = I_i^F DF_i^I , \tag{5.5.2}$$

where I_i^F is the annual intake of radionuclide i (μCi) through consumption of aquatic foods (Equation 5.4.2).

Annual dose from exposure to contaminated shoreline sediments is calculated from:

$$D_i^{SH} = E_i^{SH} DF_i^G , \tag{5.5.3}$$

where E_i^{SH} is the annual exposure to radionuclide i (μCi-yr/m^2) from Equation 5.4.3, and DF_i^G is the ground-shine dose factor (mrem-m^2/yr-μCi) taken from DOE/EH-0070 (DOE 1988c).

For swimming and boating activities, the annual dose, D_i^S, in mrem, is calculated from:

$$D_i^S = E_i^S DF_i^{WS}, \tag{5.5.4}$$

where E_i^S is the annual exposure to radionuclide i (μCi-yr/m^3) for these activities, from Equation 5.4.4, and DF_i^{WS} is the water submersion dose factor (mrem-m^3/yr-μCi) from DOE/EH-0070 (DOE 1988c). Intake of tritium via skin absorption during swimming may lead to an annual dose calculated from:

$$D_T^{skin} = I_T^{skin} DF_T^I, \tag{5.5.5}$$

where I_T^{skin} is annual intake (μCi) of tritium through the skin (Equation 5.4.5), and DF_T^I is the internal dose factor for tritium (mrem/μCi).

The half lives and dose factors used in these equations are given in Table 5.5-1.

5.5.2 Results

The equations for exposure and dose, in Sections 5.4 and 5.5.1, respectively, were applied to the surface water concentrations provided in Section 5.3 to calculate annual dose to the hypothetical individual. Calculations were done for each radionuclide for which subsurface contaminant transport was simulated. Radionuclides were selected based on the screening procedures described in Sections 4.2 and 4.4.

Calculated doses as a function of time for each radionuclide are shown in Figures 5.5-1 through 5.5-18. Zero on the time axis corresponds to the time at which waste was initially placed in the ground at the SRS, which was about 1952. The all-pathway doses as a function of time at the points of assessment (Section 2.4) on the Savannah River at the highway 301 bridge and at the mouths of Upper Three Runs and Four Mile Branch are shown in the curves labeled "301 Bridge", UTR, and FMB.

Some of the dose vs. time curves show more than one peak. For example, the curves for ^{237}Np and ^{235}U show dual peaks. Multiple peaks are due to the different release rates associated with different facilities and/or ingrowth of the radionuclide during transit in groundwater. Both ^{237}Np and ^{235}U are present in the source term initially, and are also daughters in decay chains. Therefore, the initial peaks generally correspond to the radionuclide initially present, and subsequent peaks correspond to the same radionuclide which has grown in during transit.

Figure 5.5-19 shows calculated doses from ingestion of drinking water at on-site locations selected to assess the sensitivity of results to the point of assessment (Section 6.1): curves labeled "UTR" represent doses from ingestion of water from Upper Three Runs just downstream of the GSA; curves labeled "FMB" represent doses from ingestion of water from Fourmile Branch, again just downstream of the GSA.

Figure 5.5-20 shows the sum of doses from all radionuclides as a function of time. The estimated peak all-pathway dose from all radionuclides at the points of assessment for individual dose (at the mouths of UTR and FMB and on the Savannah River) is approximately 1.8 mrem/yr., 14 mrem/yr., and 0.1 mrem/yr., respectively. Releases from the active LLW disposal facilities for which this Composite Analysis is being done, the E-Area Vaults and Saltstone facilities, contribute only to the dose calculated for UTR, because a groundwater divide isolates these facilities from FMB.

Drinking water doses for the on-site creeks potentially impacted by the GSA were calculated as part of the sensitivity analysis. The estimated peak drinking water doses from all radionuclides for these creeks are 23 mrem/yr for Fourmile Branch, and about 3 mrem/yr for Upper Three Runs. Doses at the mouths of UTR and FMB, from all pathways, were calculated as a function of stream flow as part of the sensitivity analysis. These results are presented in Figures 5.5-21 and 5.5-22. The maximum drinking water dose, corresponding to the minimum stream flow, is about 3 mrem/yr. at UTR and about 25 mrem/yr at FMB.

The major contributors to dose are ^{3}H, ^{14}C, ^{237}Np, and isotopes of uranium. At the mouths of UTR and FMB, ^{14}C is the largest contributor to the peak dose, due to consumption of aquatic foods.. At the highway 301 bridge on the Savannah River, ^{3}H and ^{14}C contribute about equally. Drinking water is the largest source of the tritium dose in the Savannah River. Neptunium-237 and the isotopes of uranium are significant dose contributors between 350 and 700 years.. The peak dose attributable to each of these radionuclides is broken down by pathway in Table 5.5-2.

Table 5.5-1 Factors Used in Dose Calculations

Radio-nuclide	Decay Constant (1/day)	Ingestion Dose Factor (rem/μCi)	Ground Shine Dose Factor (mrem m^2) (yr μCi)	Water Immersion Dose Factor (mrem m^3) (yr μCi)	Freshwater Fish Accumulation Factor (L/kg)	Saltwater Invertebrate Accumulation Factor (L/kg)
H-3	1.54E-04	6.30E-05	0.00E+00	0.00E+00	9.00E-01	9.30E-01
C-14	3.31E-07	2.10E-03	0.00E+00	0.00E+00	4.60E+03	1.40E+03
Ni-59	2.53E-08	2.00E-04	4.16E-02	4.84E-04	1.00E+02	2.50E+02
Se-79	2.92E-08	8.30E-03	0.00E+00	0.00E+00	1.70E+02	1.00E+03
Sr-90	6.64E-05	1.30E-01	0.00E+00	0.00E+00	3.00E+01	2.00E+01
Zr-93	1.27E-09	1.60E-03	0.00E+00	0.00E+00	3.30E+00	8.00E+01
Nb-93m	1.40E-04	5.30E-03	1.03E-01	1.75E-03	3.00E+04	1.00E+02
Nb-94	9.35E-08	5.10E-03	1.59E+02	1.77E+01	3.00E+04	1.00E+02
Tc-99	8.91E-09	1.30E-03	6.26E-05	6.18E-06	1.50E+01	5.00E+01
Sn-126	1.90E-08	1.70E-02	6.18E+00	5.75E-01	3.00E+03	1.00E+03
I-129	1.21E-10	2.80E-01	2.20E+00	1.07E-01	1.50E+01	5.00E+01
Pb-210	8.53E-05	5.10E+00	3.00E-01	1.68E-02	3.00E+02	1.00E+03
Bi-210	1.38E-01	5.90E-03	0.00E+00	0.00E+00	1.50E+01	0.00E+00
Po-210	5.01E-03	1.60E+00	8.60E-04	9.57E-05	5.00E+02	2.00E+04
Ra-226	1.19E-06	1.10E+00	7.60E-01	7.64E-02	5.00E+01	1.00E+02
Ac-227	8.72E-05	1.40E+01	2.12E-02	1.44E-03	2.50E+01	1.00E+03
Th-230	2.47E-08	5.30E-01	9.07E-02	4.64E-03	3.00E+01	2.00E+03
Th-231	6.52E-01	1.30E-03	1.91E+00	1.37E-01	3.00E+01	2.00E+03
Th-232	1.35E-13	2.80E+00	6.66E-02	2.26E-03	3.00E+01	2.00E+03
Th-234	2.88E-02	1.3E-02	6.69E+01	9.13E-02	3.00E+01	2.00E+03
Pa-231	5.80E-08	1.10E+01	3.58E+00	3.34E-01	1.10E+01	1.00E+01
Pa-233	2.57E-02	3.30E-03	2.36E+01	2.37E+00	1.10E+01	1.00E+01
U-233	1.19E-08	2.70E-01	5.00E-02	2.76E-03	2.00E+00	1.00E+01
U-234	7.77E-09	2.60E-01	8.07E-02	1.86E-03	2.00E+00	1.00E+01
U-235	2.70E-12	2.50E-01	1.71E+01	1.72E+00	2.00E+00	1.00E+01
U-236	8.11E-11	2.50E-01	7.33E-02	1.50E-03	2.00E+00	1.00E+01
U-238	4.25E-13	2.30E-01	6.46E-02	1.29E-03	2.00E+00	1.00E+01
Np-237	8.87E-10	3.90E+00	3.24E+00	2.68E-01	1.00E+01	1.00E+01
Pu-238	2.16E-05	3.80E+00	8.58E-02	1.12E-03	3.50E+00	2.00E+02
Pu-239	7.87E-08	4.30E+00	3.78E-02	9.74E-04	3.50E+00	2.00E+02
Pu-240	2.89E-07	4.30E+00	8.20E-02	1.10E-03	3.50E+00	2.00E+02
Pu-241	1.32E-04	8.60E-02	0.00E+00	0.00E+00	3.50E+00	2.00E+02
Pu-242	5.05E-09	4.10E+00	6.82E-02	9.32E-04	3.50E+00	2.00E+02
Am-241	4.39E-06	4.50E+00	2.99E+00	2.33E-01	2.50E+01	1.00E+03
Am-243	2.57E-07	4.50E+00	6.61E+00	6.09E-01	2.50E+01	1.00E+03
Cm-244	1.05E-04	2.30E+00	8.29E-02	1.07E-03	2.50E+01	1.00E+03
Cm-246	4.00E-07	4.50E+00	7.34E-02	9.01E-04	2.50E+01	1.00E+03

Table 5.5-2 **Peak dose, broken down by pathway, for major contributors to individual dose for points of assessment on Savannah River, Upper Three Runs, and Fourmile Branch**

Radio-nuclide	Time of Peak Dose (yr)	Fish Ingestion Dose mrem/yr	Water Ingestion Dose mrem/yr	Shoreline Dose mrem/yr	Swimming Dose mrem/yr	Boating Dose mrem/yr	Dose All Pathways mrem/yr
Savannah River, 301 Bridge							
H-3	62	1.9E-03	8.1E-02	0.0E+00	3.5E-05	0.0E+00	8.3E-02
C-14	692	6.6E-02	5.5E-04	0.0E+00	0.0E+00	0.0E+00	6.7E-02
Np-237	478	1.6E-03	6.3E-03	3.8E-06	6.1E-10	7.2E-10	7.9E-03
U-233	378	1.0E-05	2.0E-04	2.7E-08	2.8E-12	3.4E-12	2.1E-04
U-234	395	2.2E-04	4.3E-03	9.7E-07	4.3E-11	5.1E-11	4.5E-03
U-235	362	9.1E-06	1.8E-04	8.7E-06	1.7E-09	2.0E-09	1.9E-04
U-236	356	2.7E-05	7.0E-04	1.5E-07	5.9E-12	7.0E-12	7.3E-04
U-238	370	2.5E-04	4.6E-03	9.3E-07	3.6E-11	4.2E-11	4.9E-03
Upper Three Runs, near mouth at Savannah River							
H-3	62	5.9E-02	NA[a]	0.0E+00	1.1E-03	0.0E+00	6.0E-02
C-14	728	1.8E+00	NA[a]	0.0E+00	0.0E+00	0.0E+00	1.8E+00
Np-237	685	2.2E-02	NA[a]	5.2E-05	8.2E-09	9.6E-09	2.2E-02
U-233	545	3.0E-04	NA[a]	7.7E-07	8.1E-11	9.6E-11	3.0E-04
U-234	383	6.9E-03	NA[a]	3.1E-05	1.3E-09	1.6E-09	6.9E-03
U-235	548	2.4E-04	NA[a]	2.4E-04	4.5E-08	5.3E-08	4.8E-04
U-236	549	9.6E-04	NA[a]	3.9E-06	1.5E-10	1.8E-10	9.6E-04
U-238	551	6.5E-03	NA[a]	2.6E-05	9.7E-10	1.1E-09	6.5E-03
Fourmile Branch, near mouth at Savannah River							
H-3	61	3.2E-01	NA[a]	0.0E+00	5.8E-03	0.0E+00	3.2E-01
C-14	592	1.3E+01	NA[a]	0.0E+00	0.0E+00	0.0E+00	1.3E+01
Np-237	476	7.0E-01	NA[a]	1.6E-03	2.5E-07	3.0E-07	7.0E-01
U-233	378	1.9E-03	NA[a]	4.9E-06	5.2E-10	6.2E-10	1.9E-03
U-234	411	3.6E-02	NA[a]	1.6E-04	7.0E-09	8.2E-09	3.6E-02
U-235	344	2.2E-03	NA[a]	2.2E-03	4.1E-07	4.9E-07	4.4E-03
U-236	340	9.8E-03	NA[a]	5.0E-05	1.6E-09	1.8E-09	9.9E-03
U-238	348	5.6E-02	NA[a]	2.2E-04	8.3E-09	9.8E-09	5.6E-02

[a] NA = Not applicable; exposure scenario does not include ingestion of drinking water (Sect. 5.4)

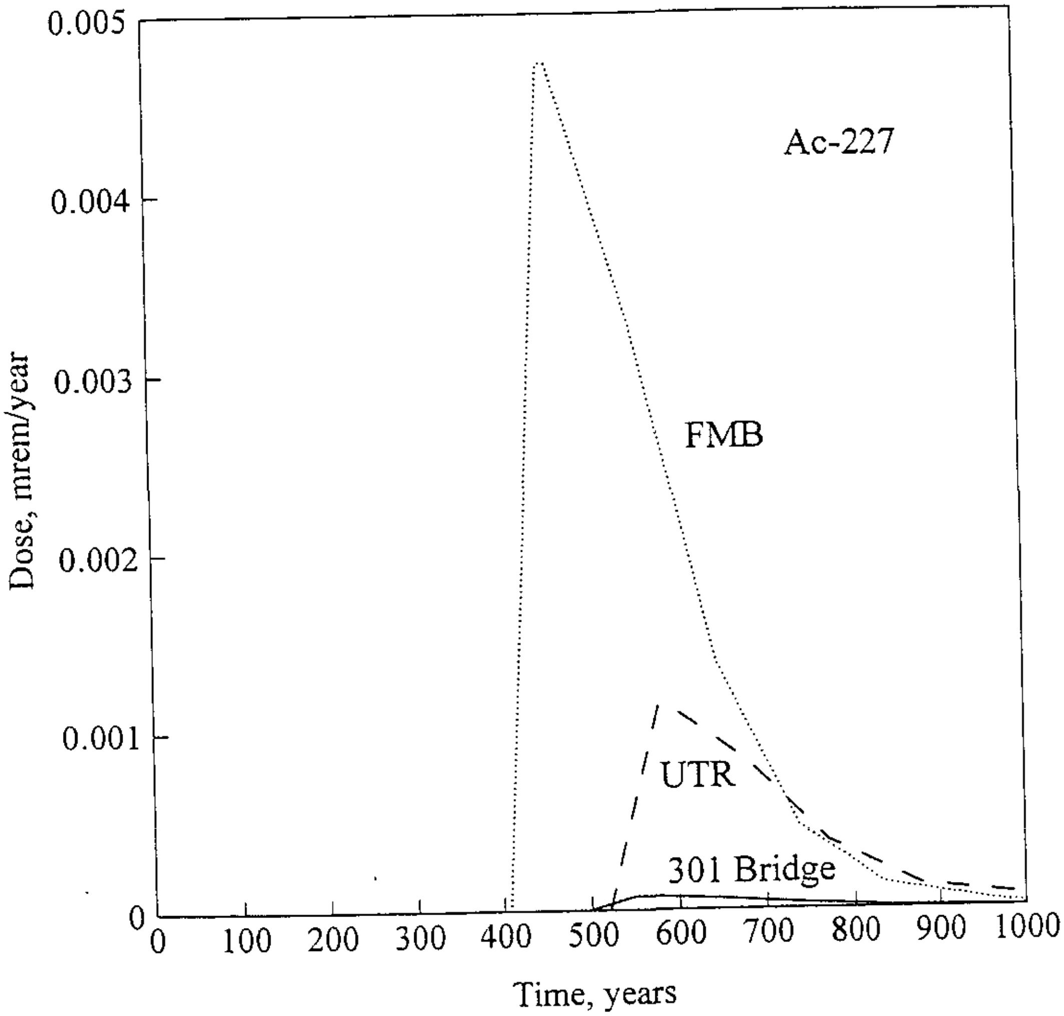

Figure 5.5-1 Dose from ^{227}Ac to the hypothetical maximally-exposed individual

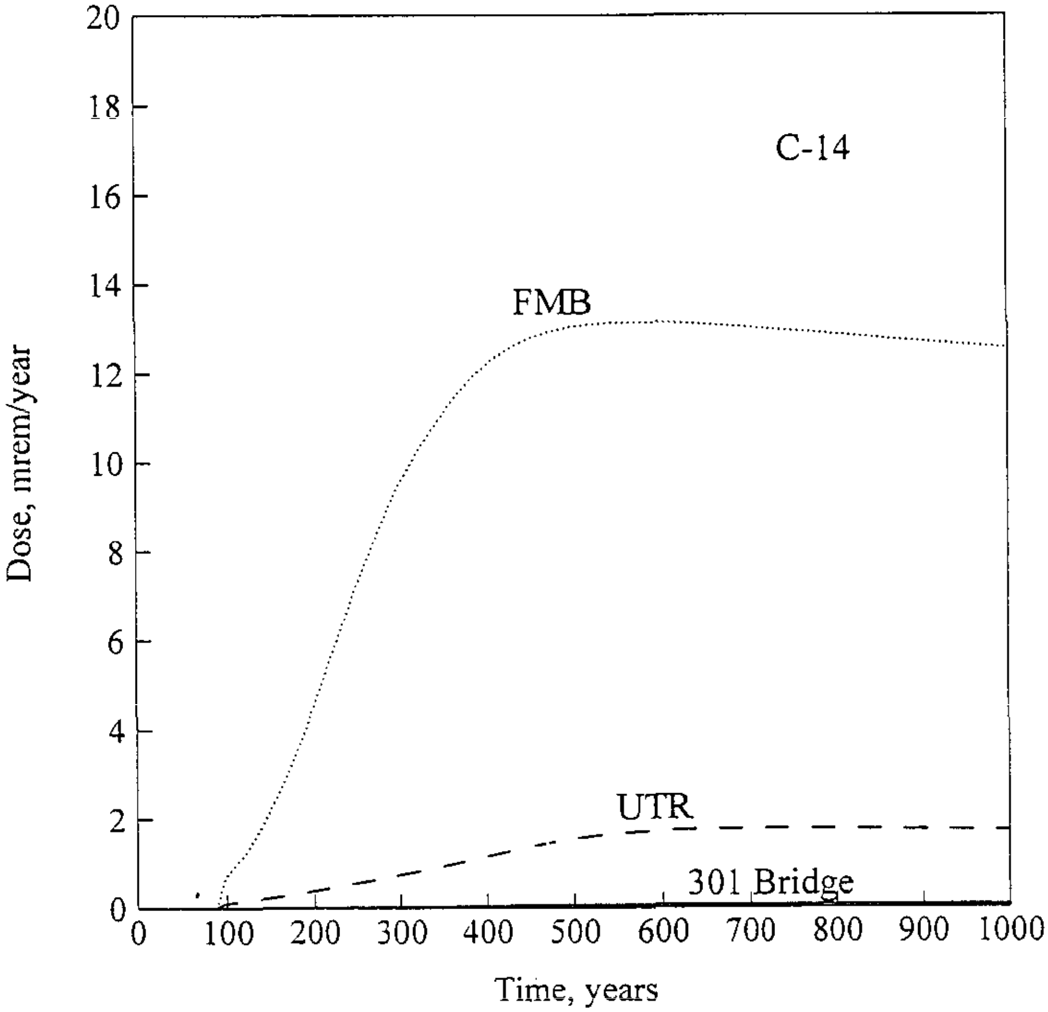

Figure 5.5-2 Dose from ^{14}C to the hypothetical maximally-exposed individual

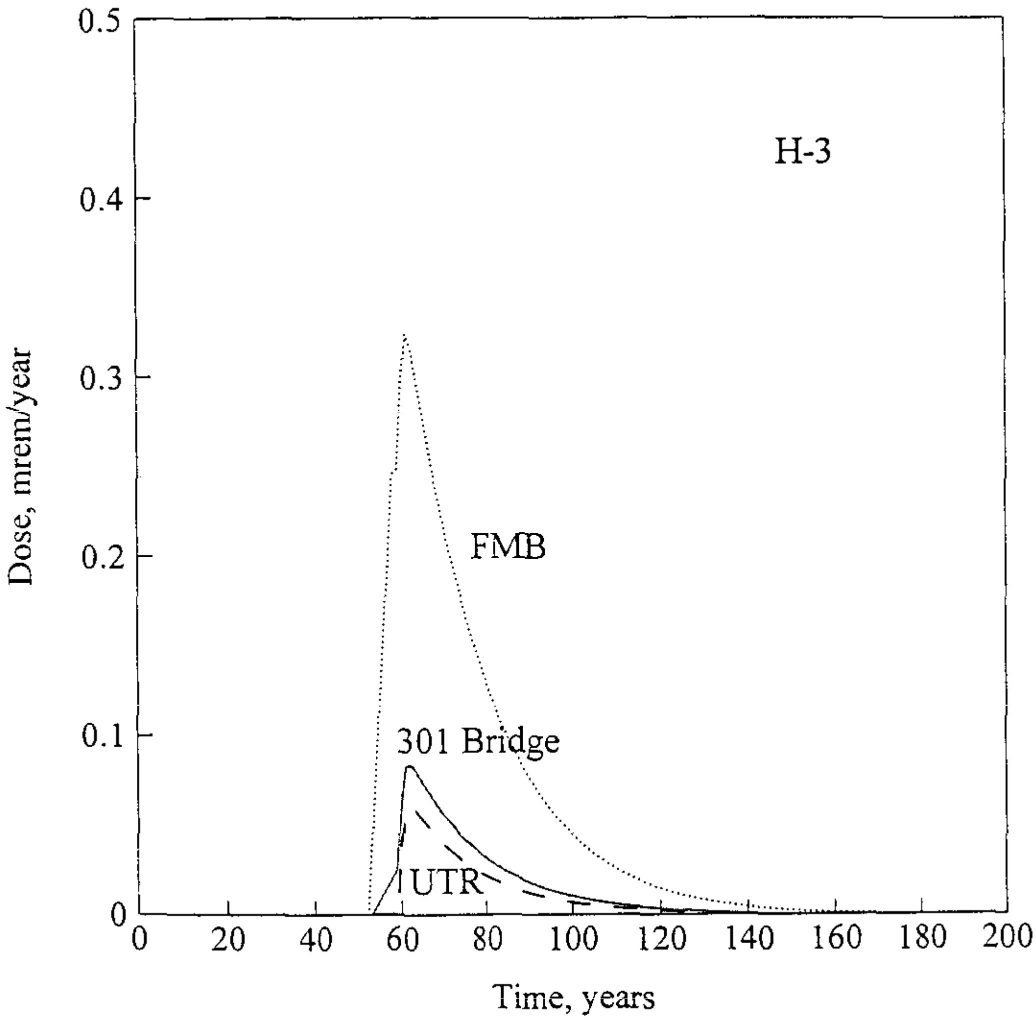

Figure 5.5-3 Dose from ^3H to the hypothetical maximally-exposed individual

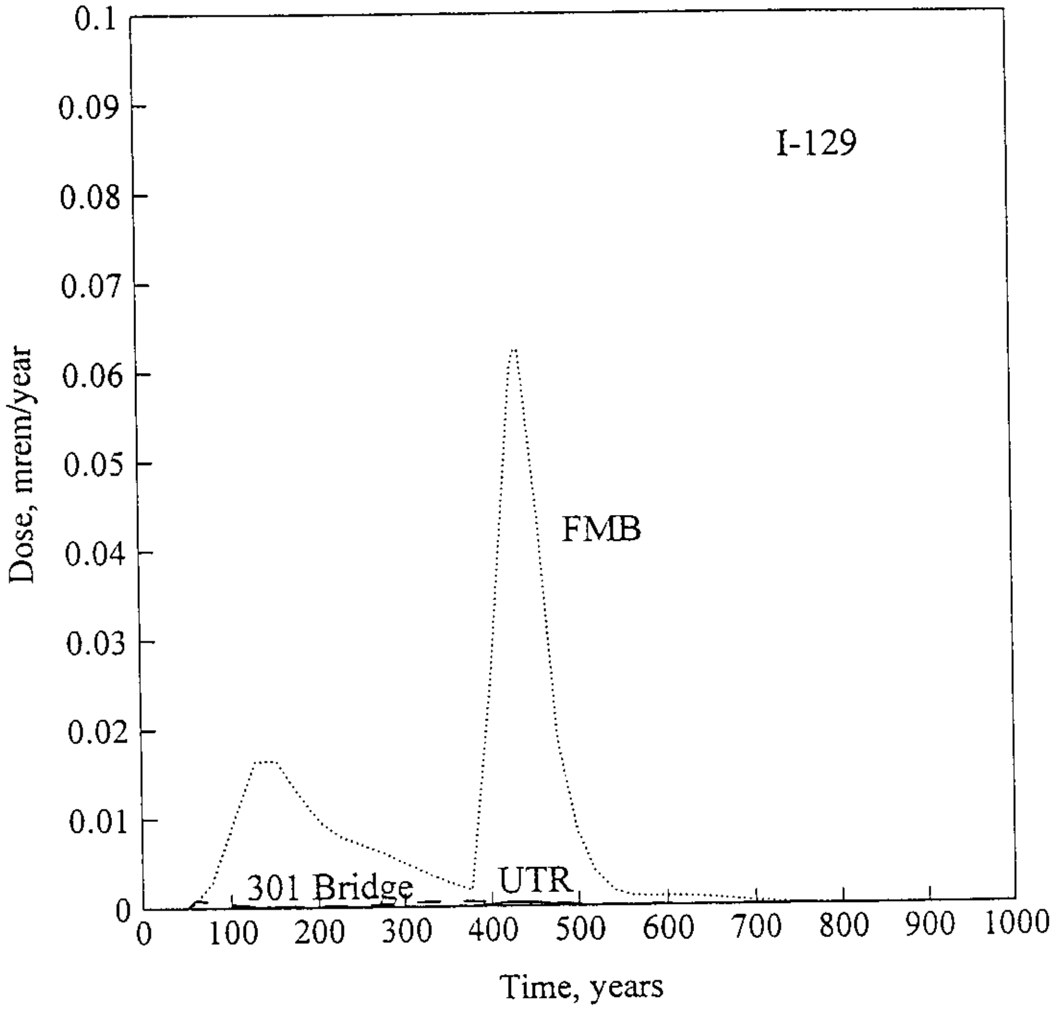

Figure 5.5-4 Dose from ^{129}I to the hypothetical maximally-exposed individual

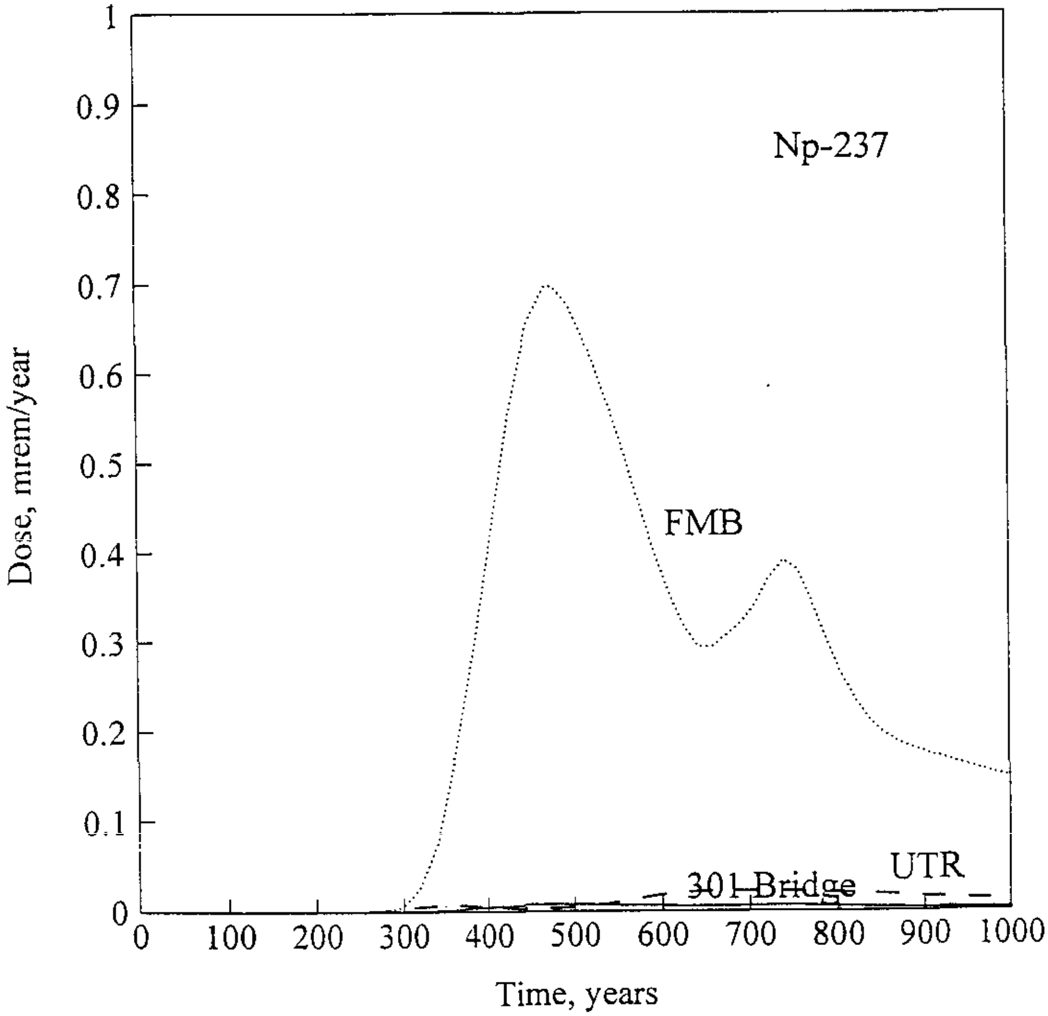

Figure 5.5-5 Dose from ^{237}Np to the hypothetical maximally-exposed individual

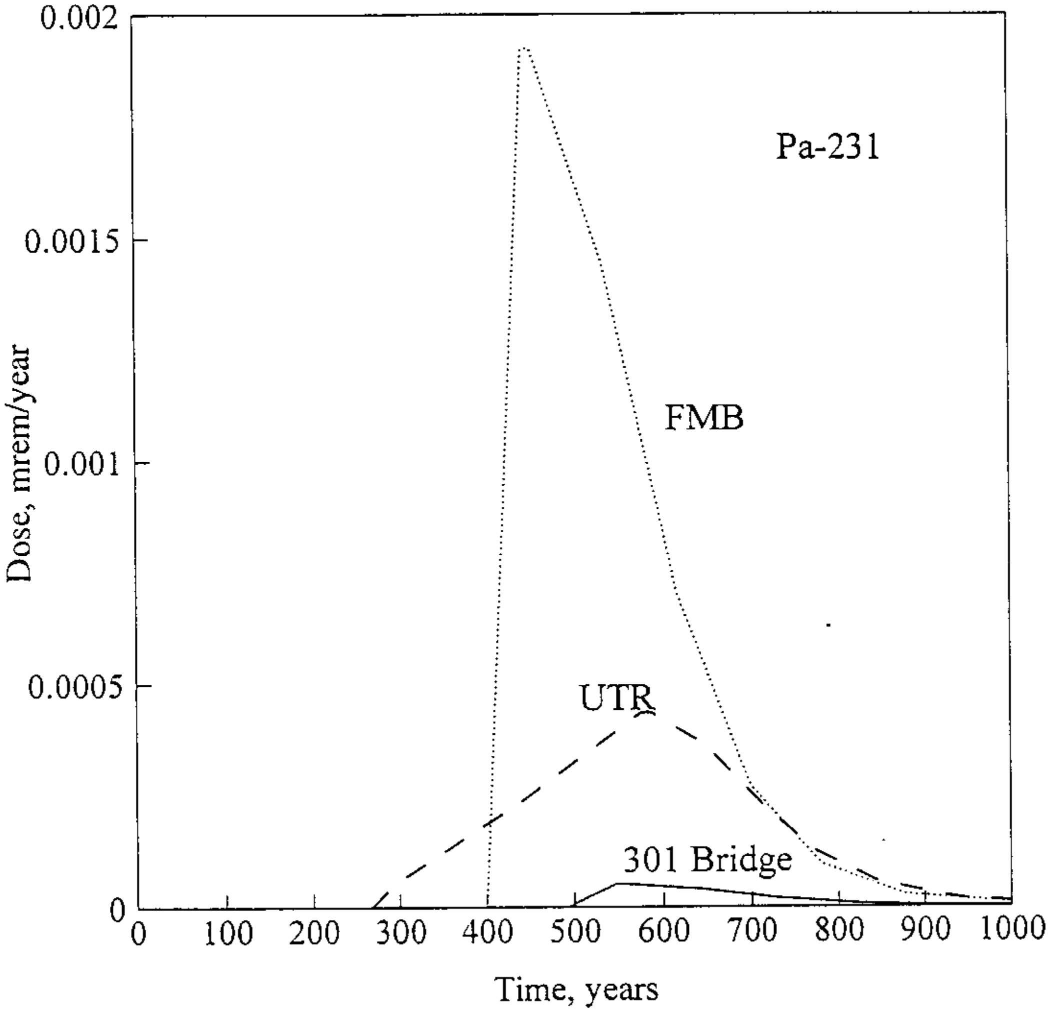

Figure 5.5-6 Dose from ^{231}Pa to the hypothetical maximally-exposed individual

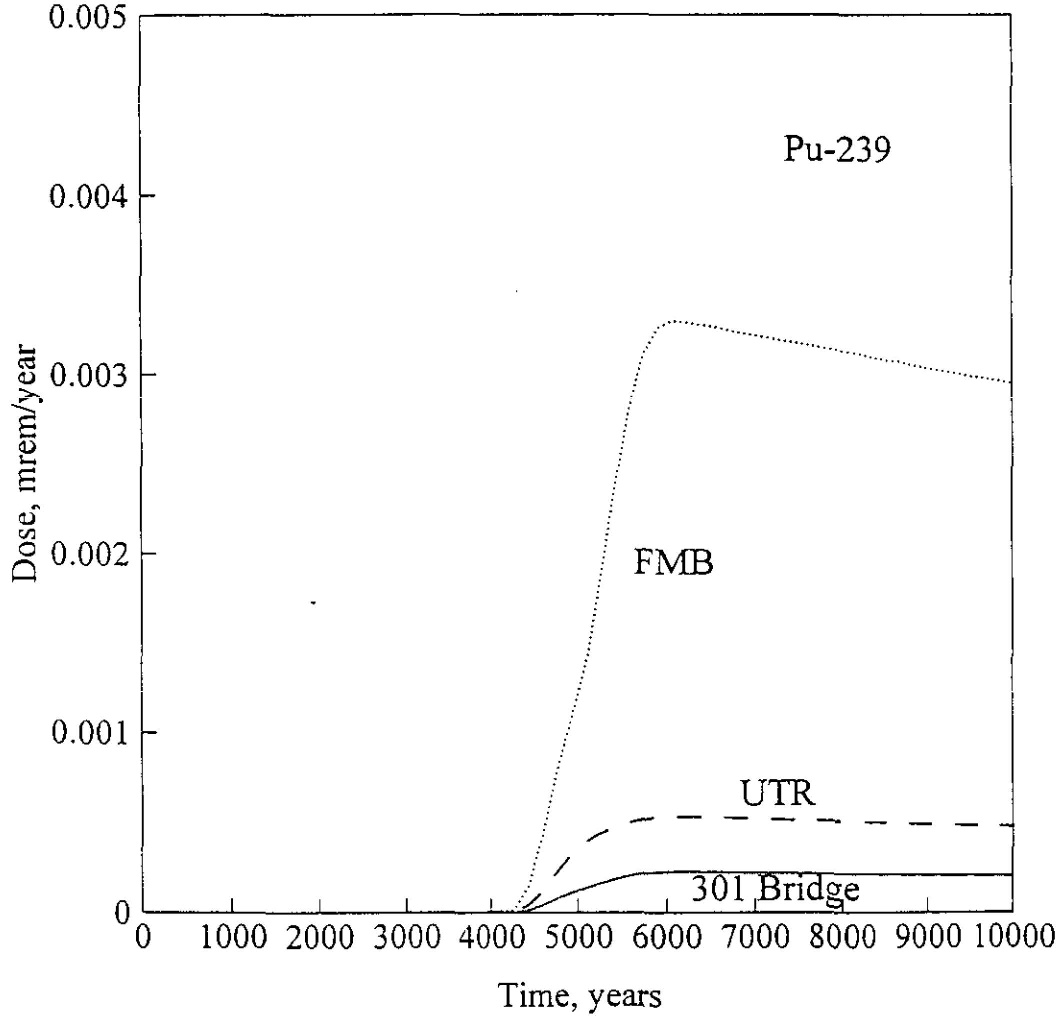

Figure 5.5-7 Dose from ^{239}Pu to the hypothetical maximally-exposed individual

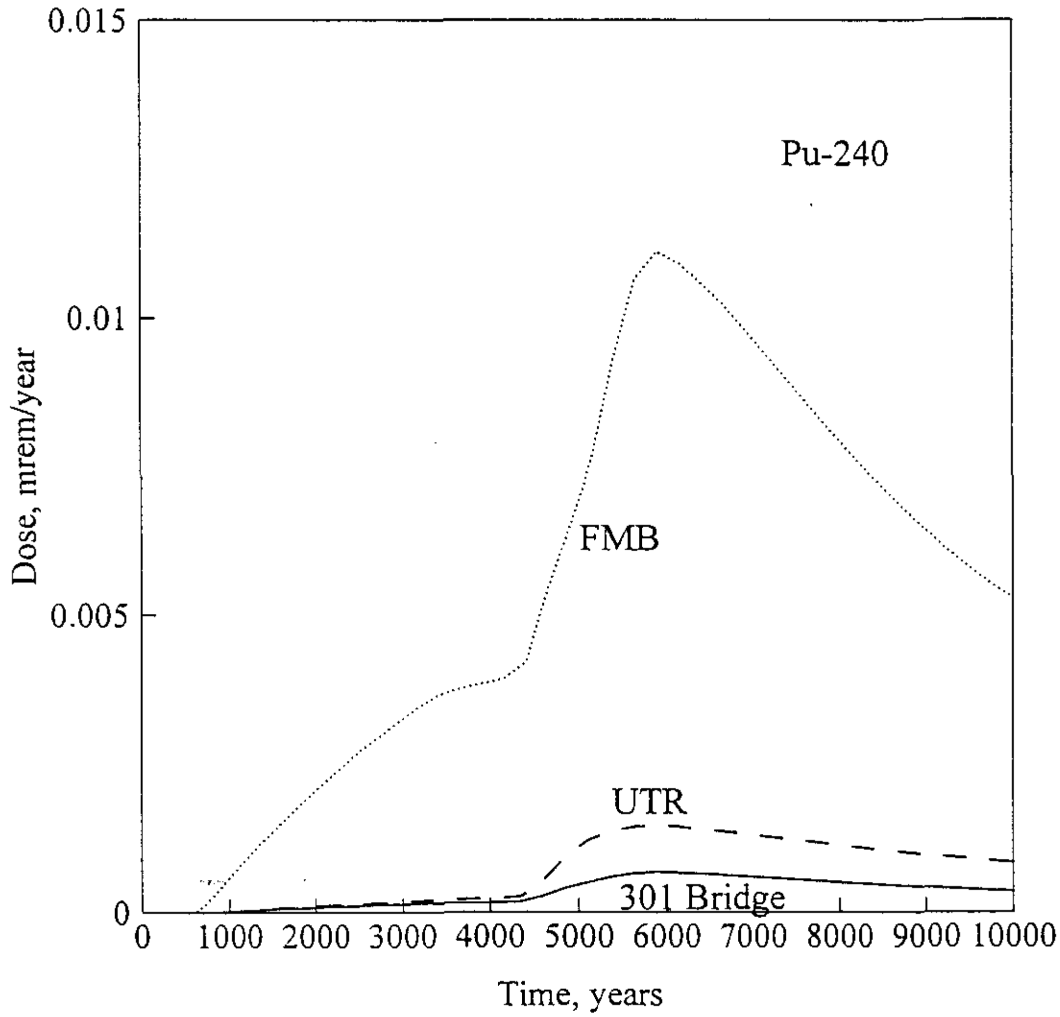

Figure 5.5-8 Dose from ^{240}Pu to the hypothetical maximally-exposed individual

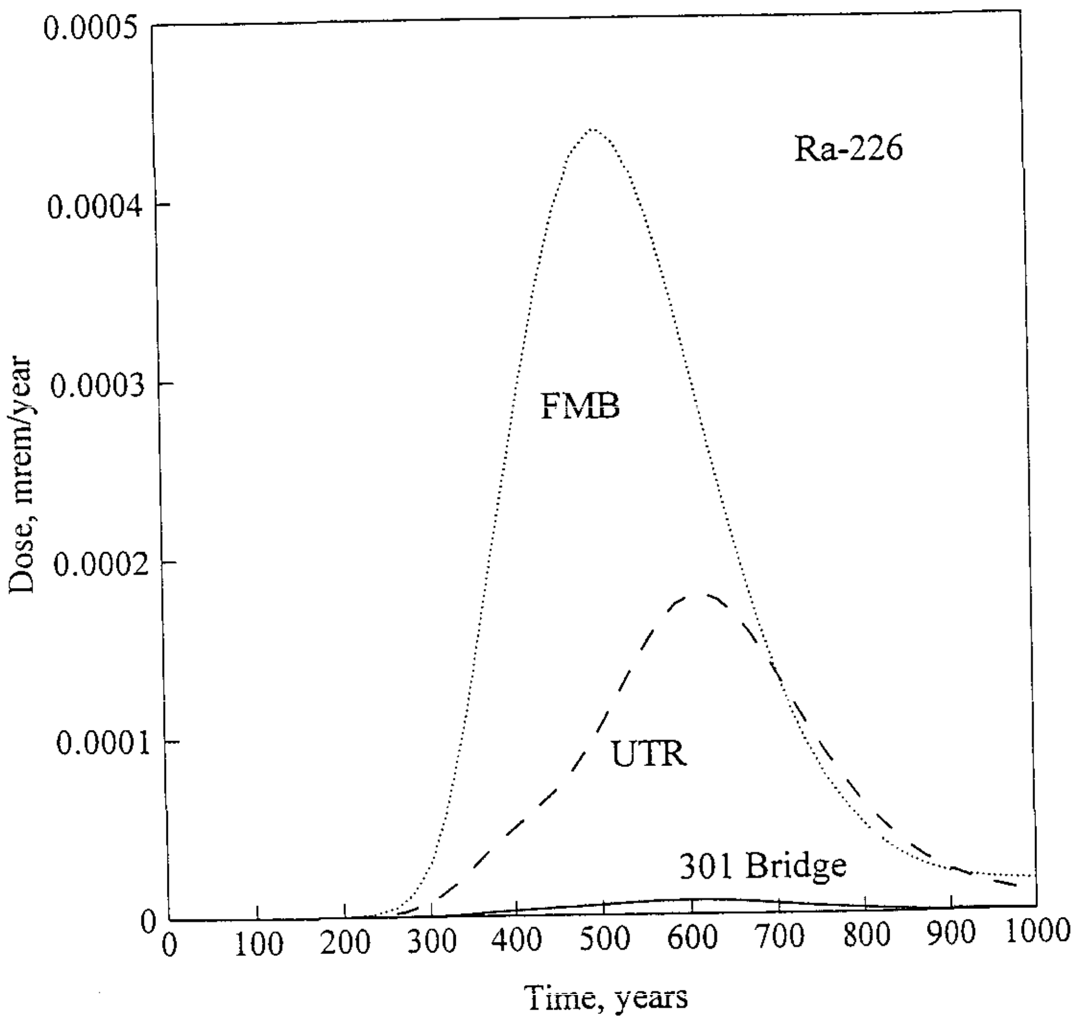

Figure 5.5-9 Dose from ^{226}Ra to the hypothetical maximally-exposed individual

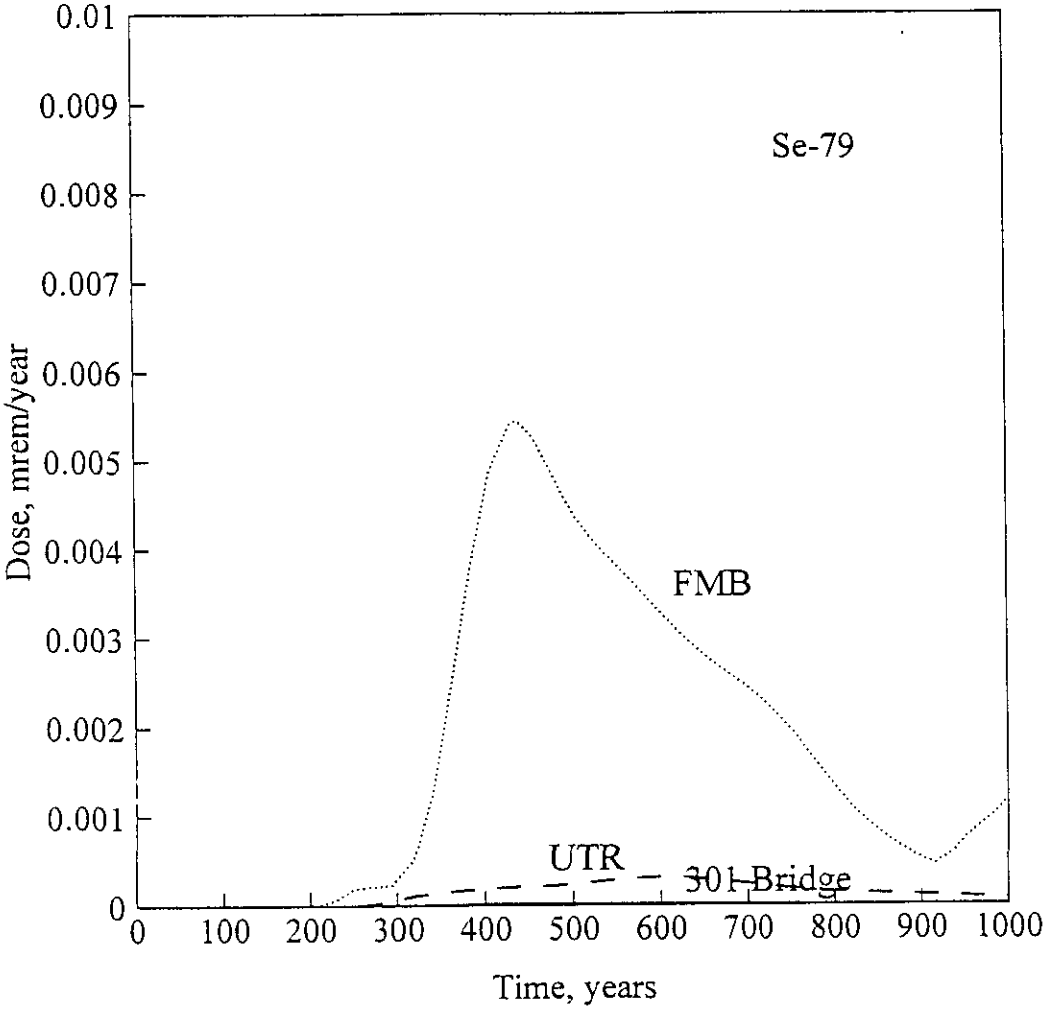

Figure 5.5-10 Dose from ^{79}Se to the hypothetical maximally-exposed individual

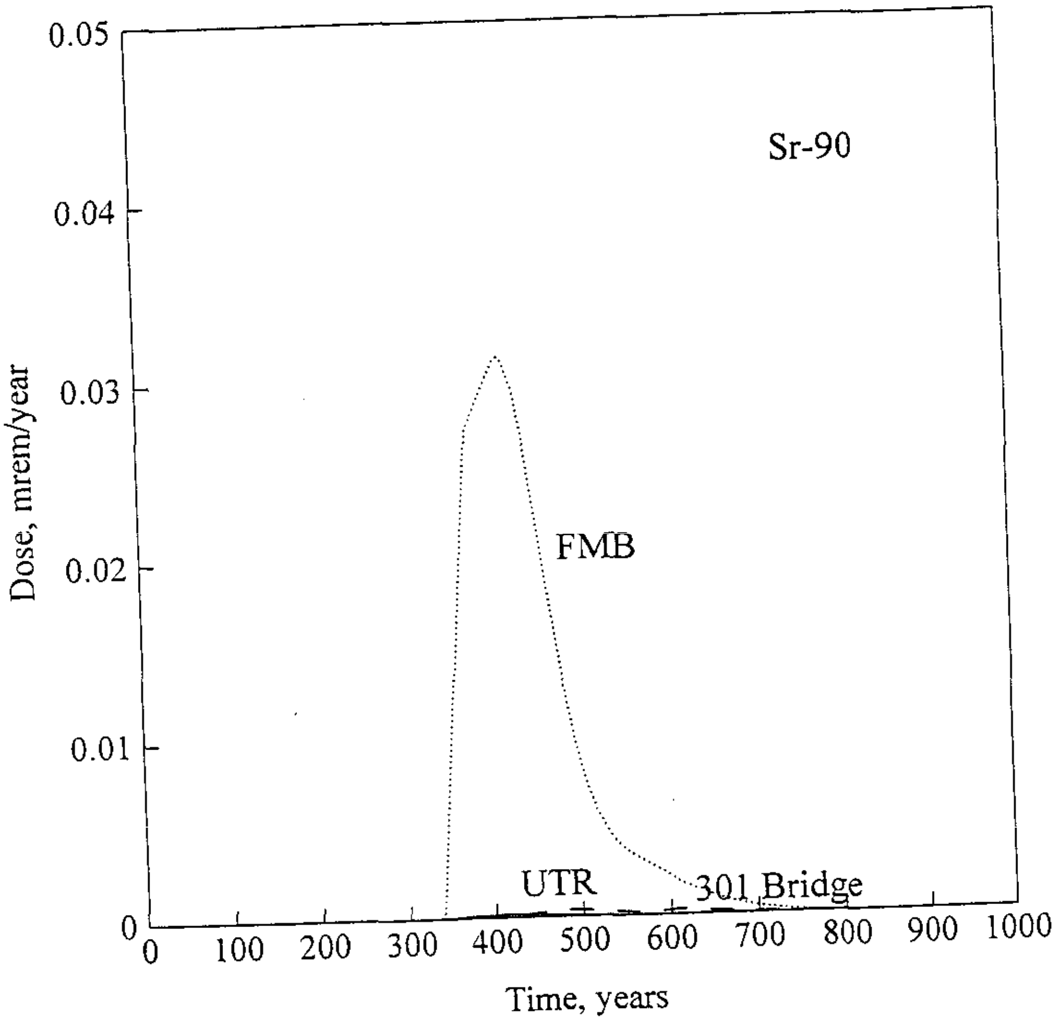

Figure 5.5-11 Dose from ^{90}Sr to the hypothetical maximally-exposed individual

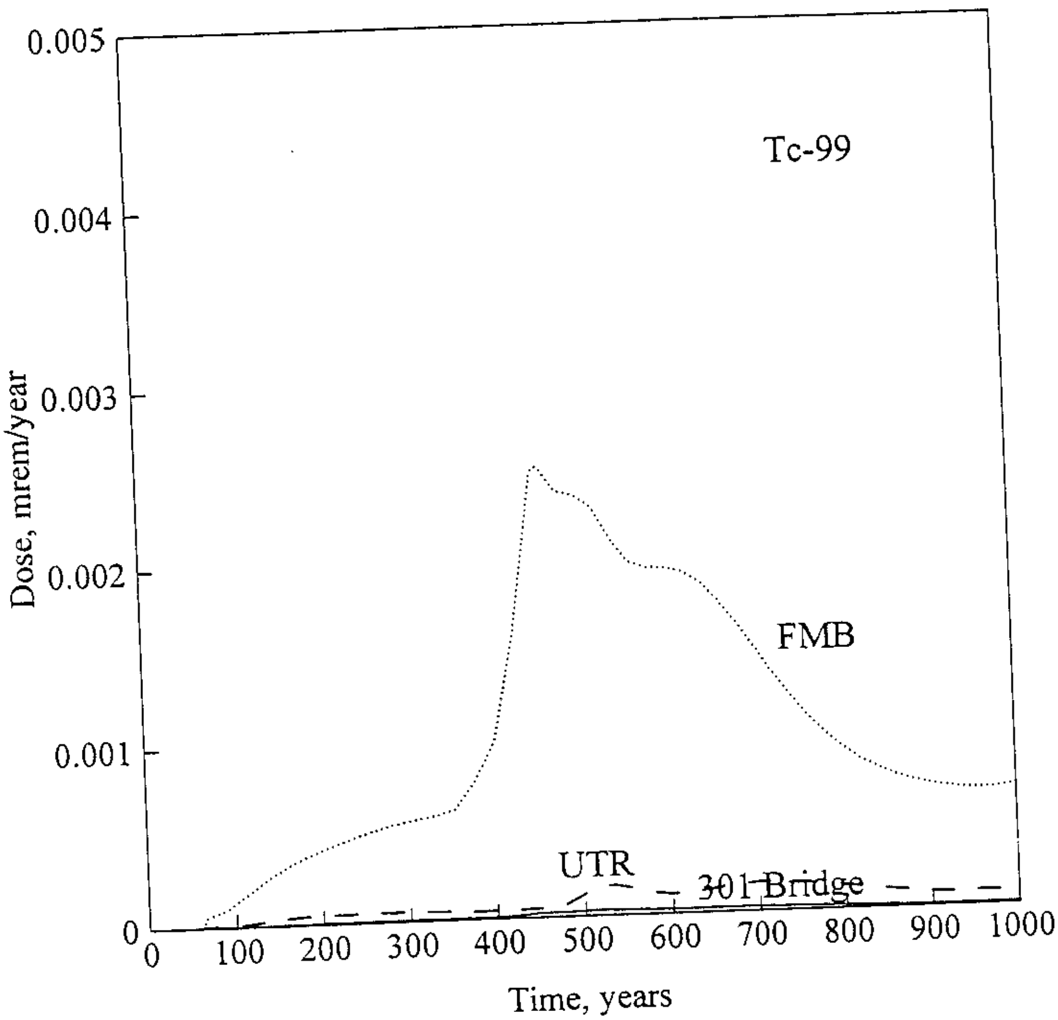

Figure 5.5-12 Dose from ^{99}Tc to the hypothetical maximally-exposed individual

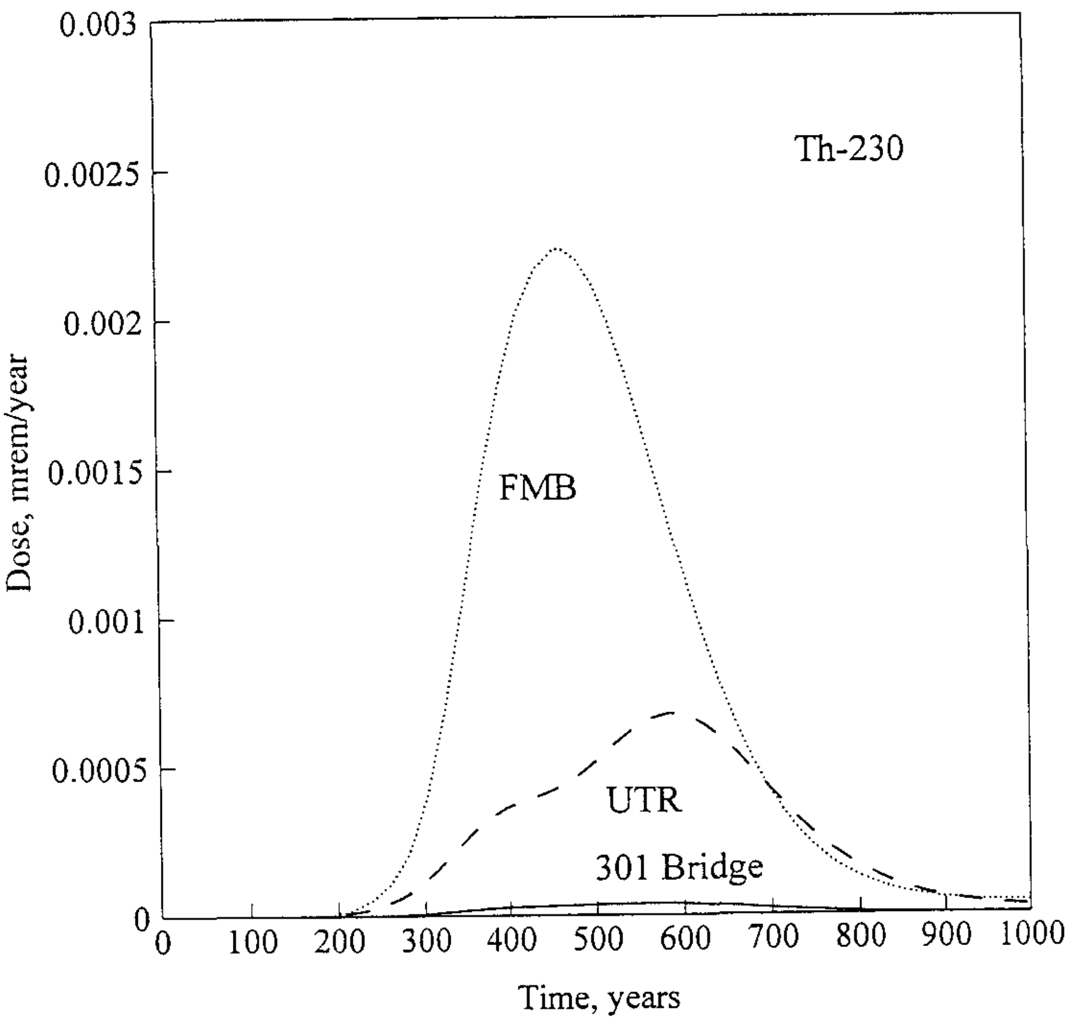

Figure 5.5-13 Dose from ^{230}Th to the hypothetical maximally-exposed individual

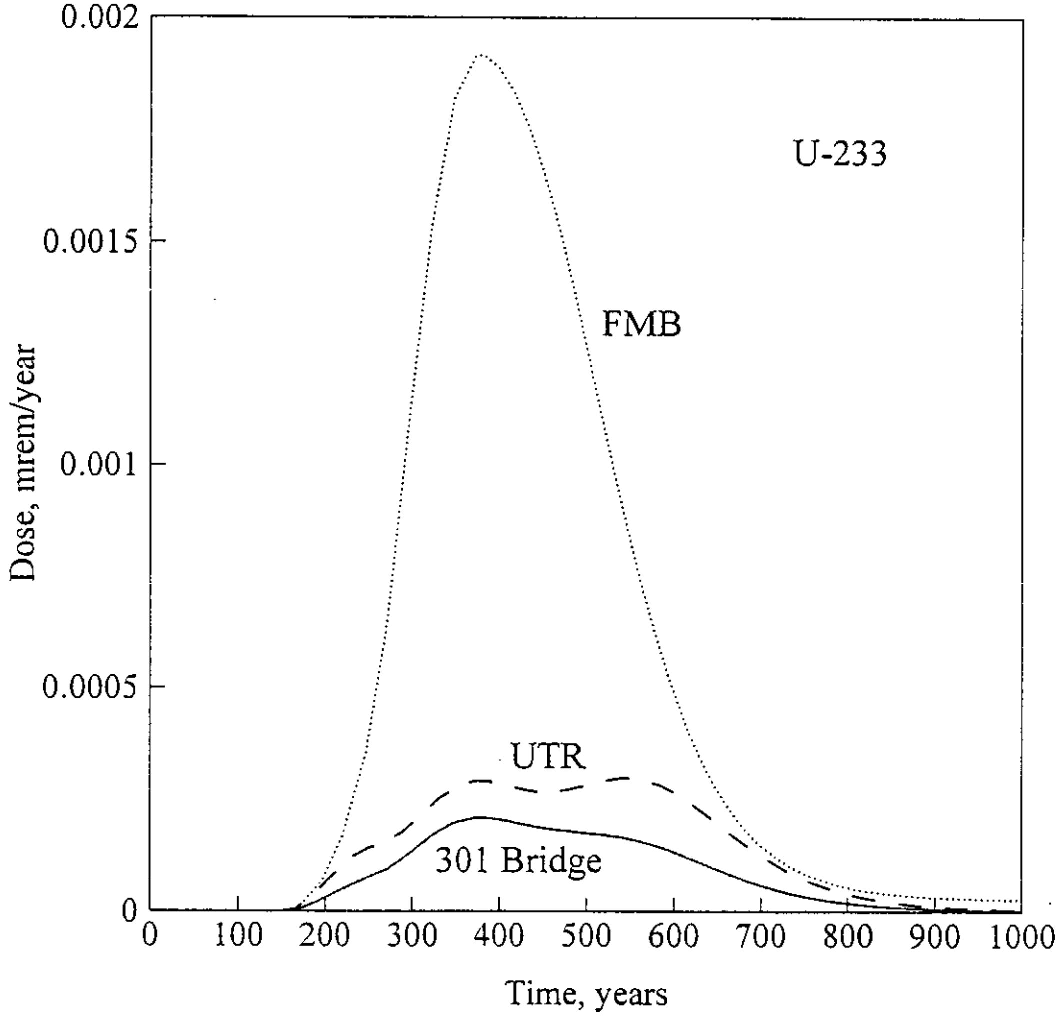

Figure 5.5-14 Dose from ^{233}U to the hypothetical maximally-exposed individual

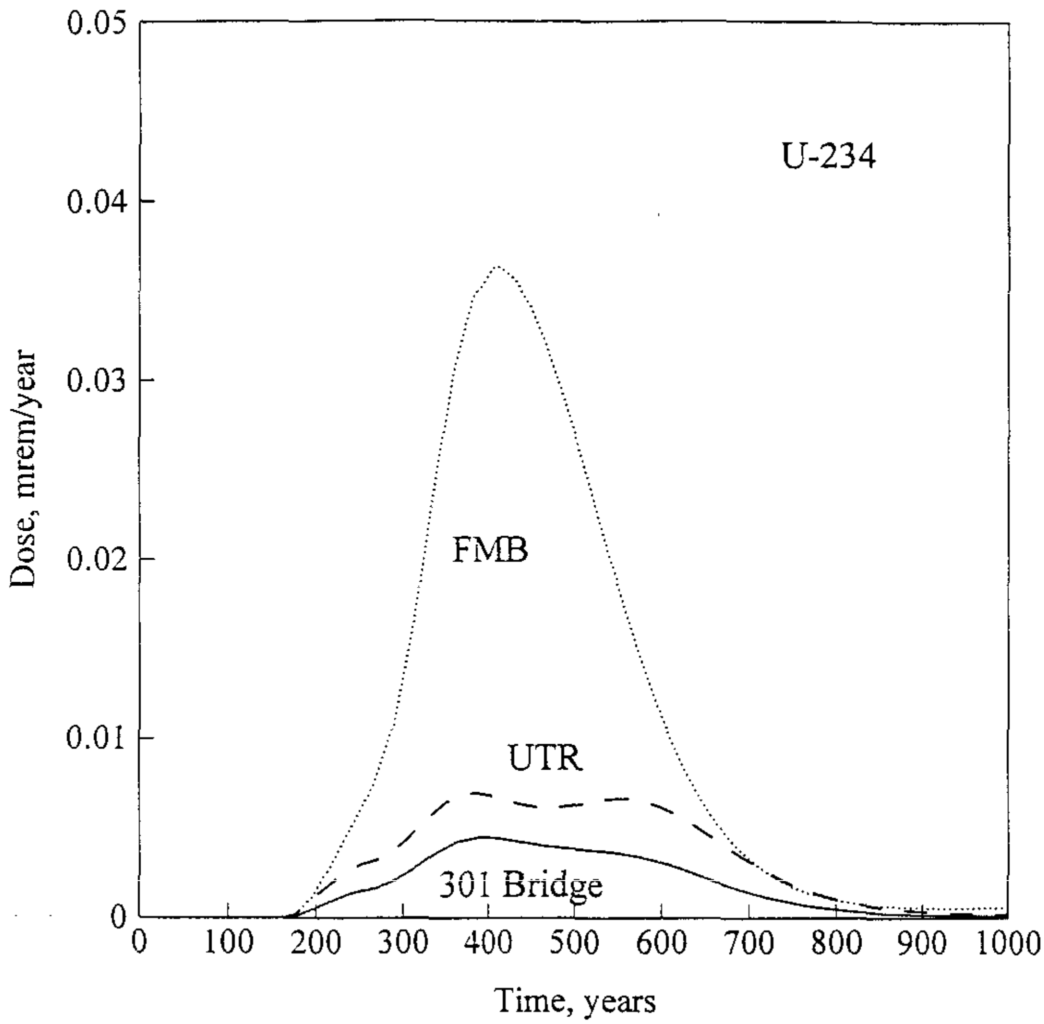

Figure 5.5-15 Dose from ^{234}U to the hypothetical maximally-exposed individual

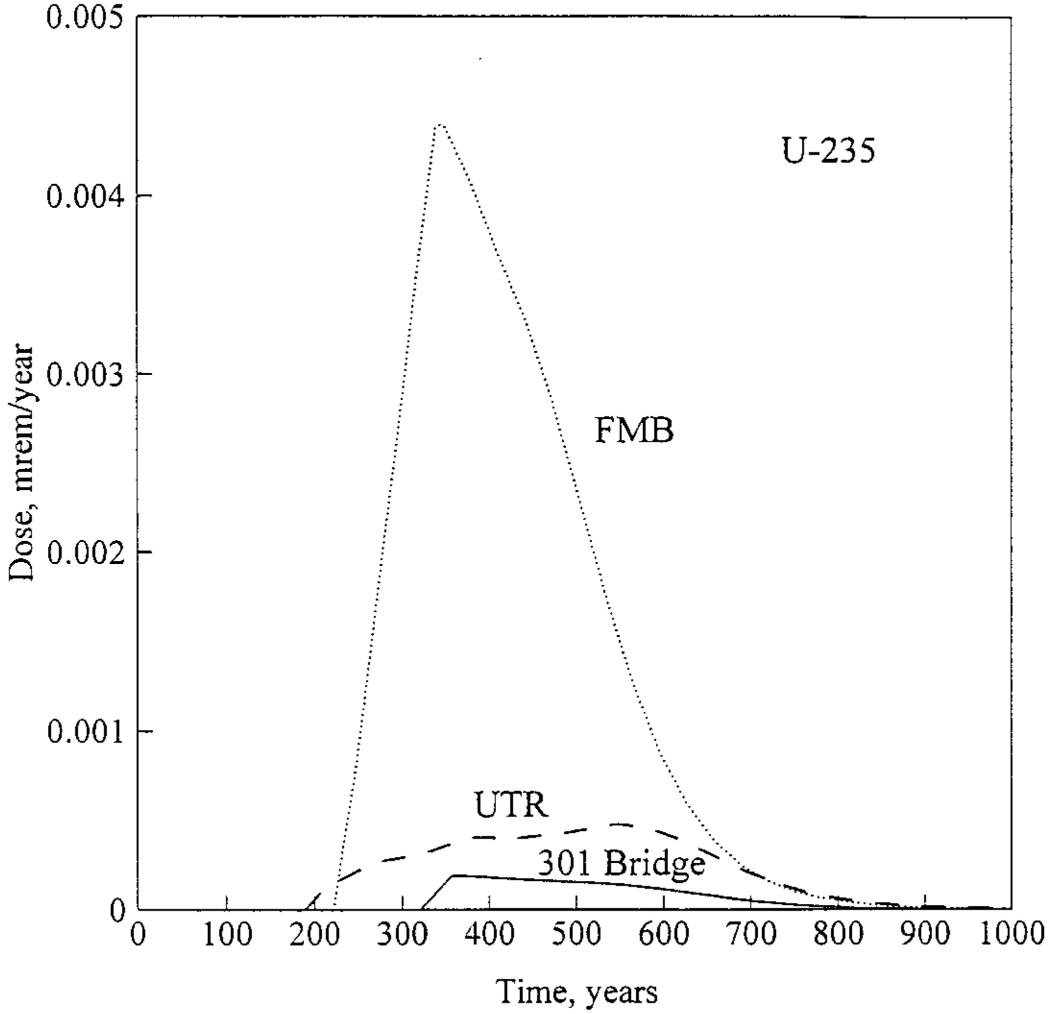

Figure 5.5-16 Dose from ^{235}U to the hypothetical maximally-exposed individual

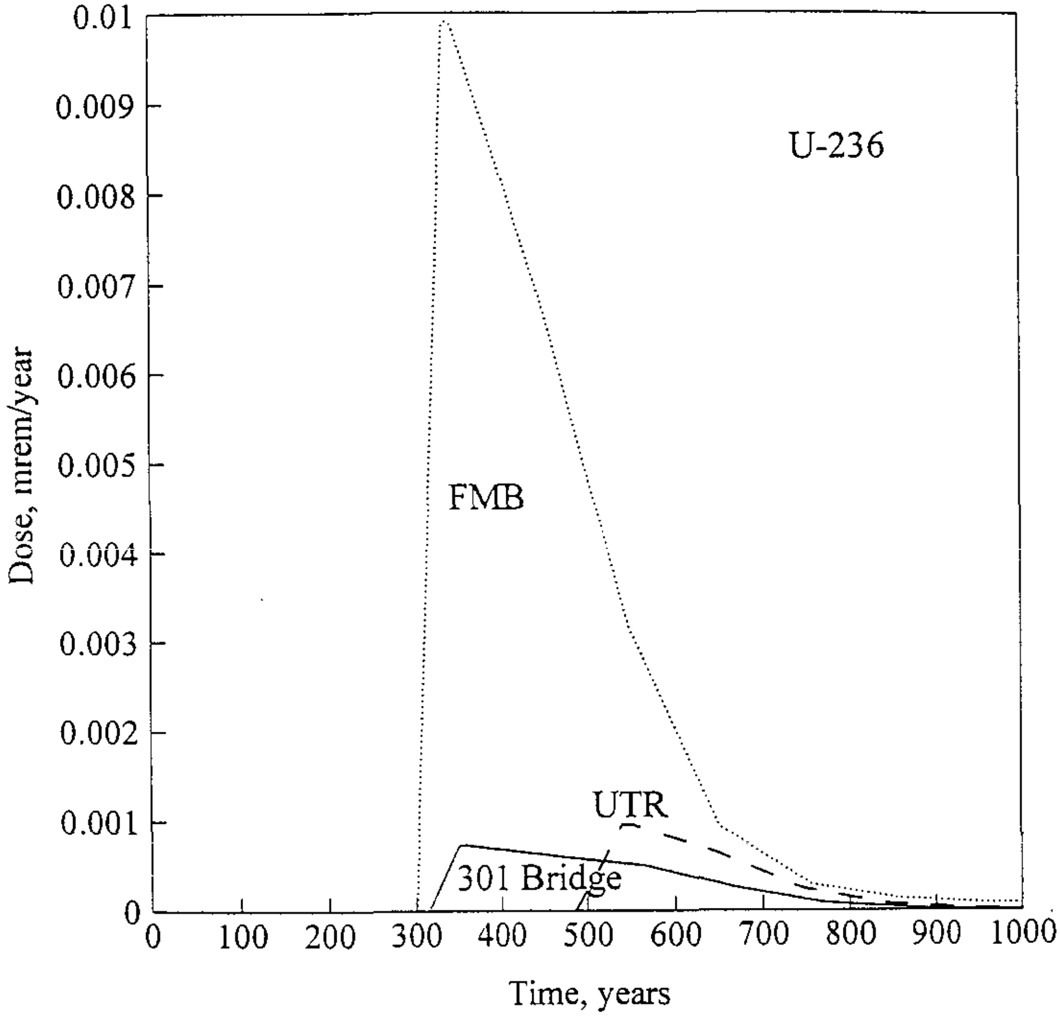

Figure 5.5-17 Dose from ^{236}U to the hypothetical maximally-exposed individual

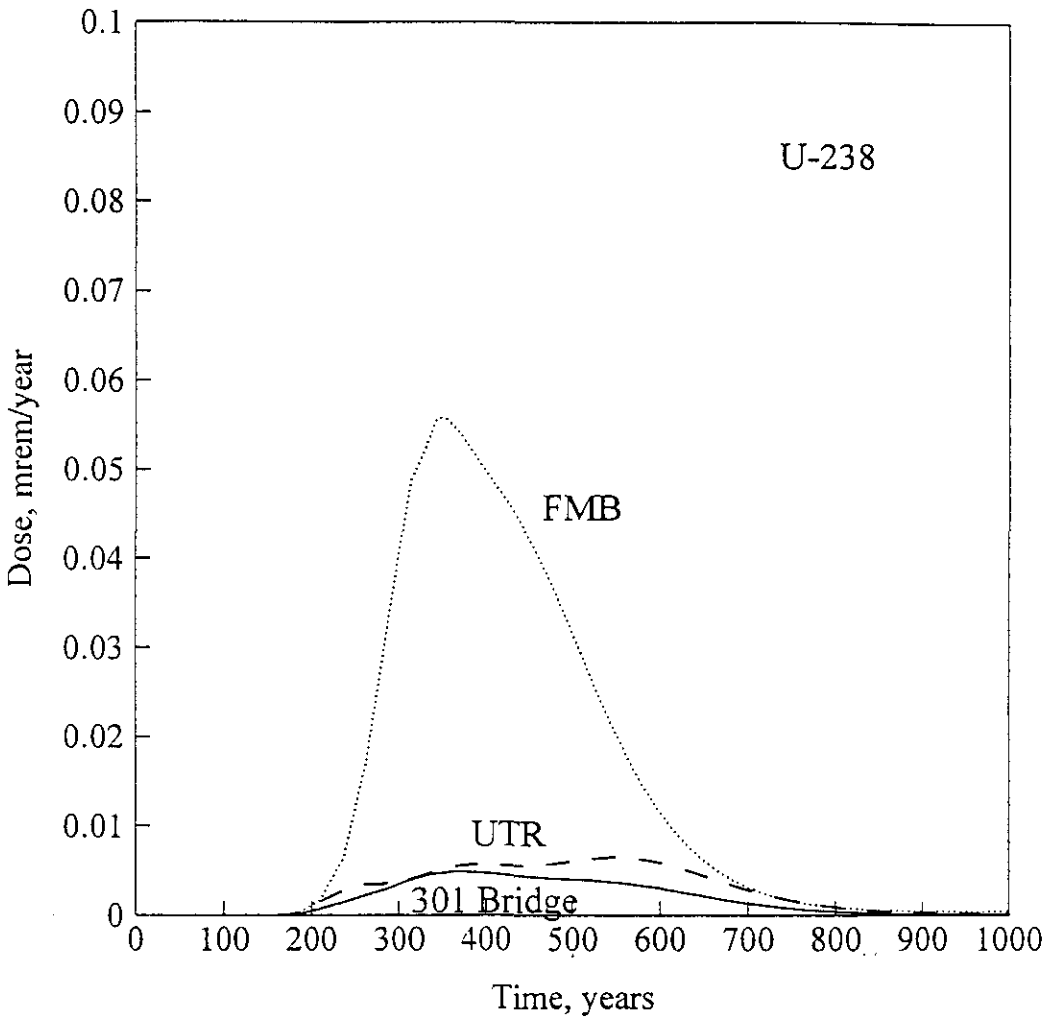

Figure 5.5-18 Dose from ^{238}U to the hypothetical maximally-exposed individual

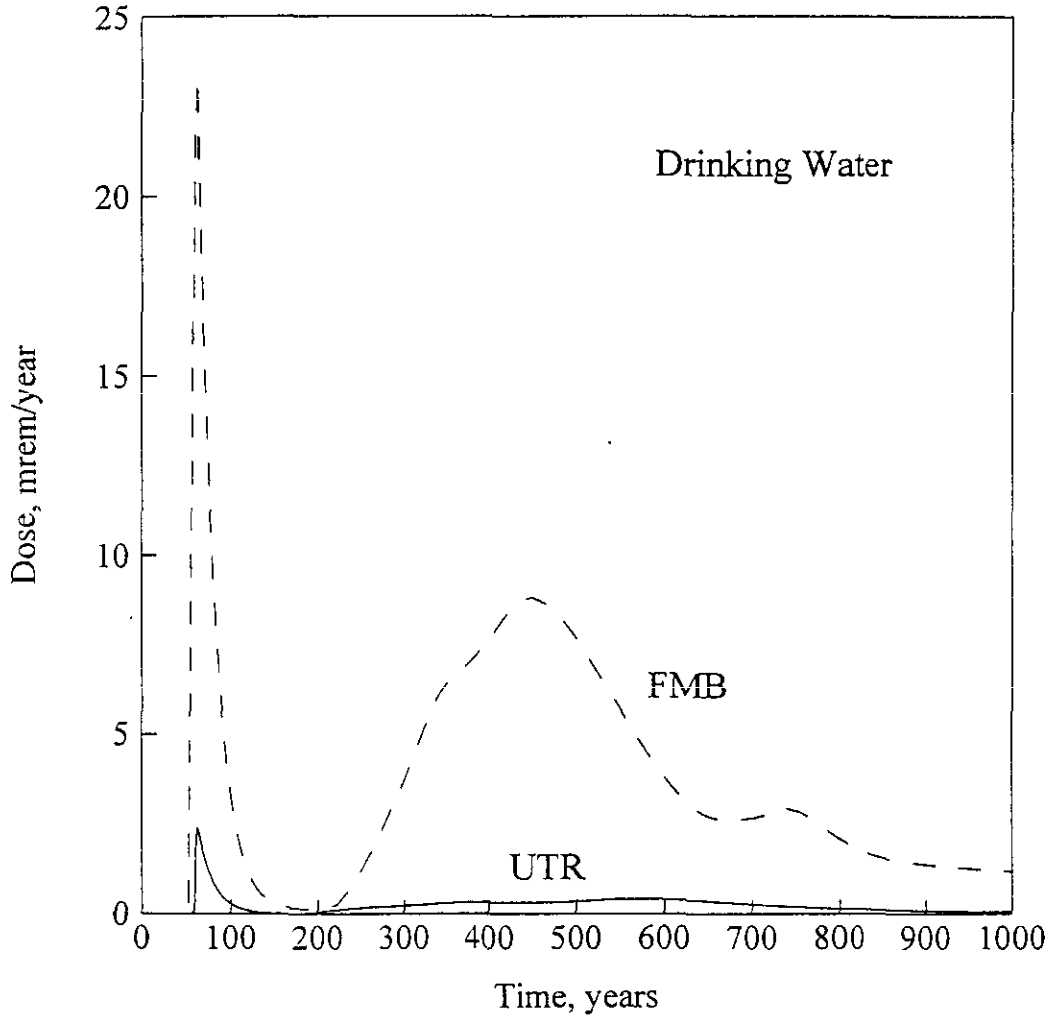

Figure 5.5-19 Drinking water doses at points within the GSA

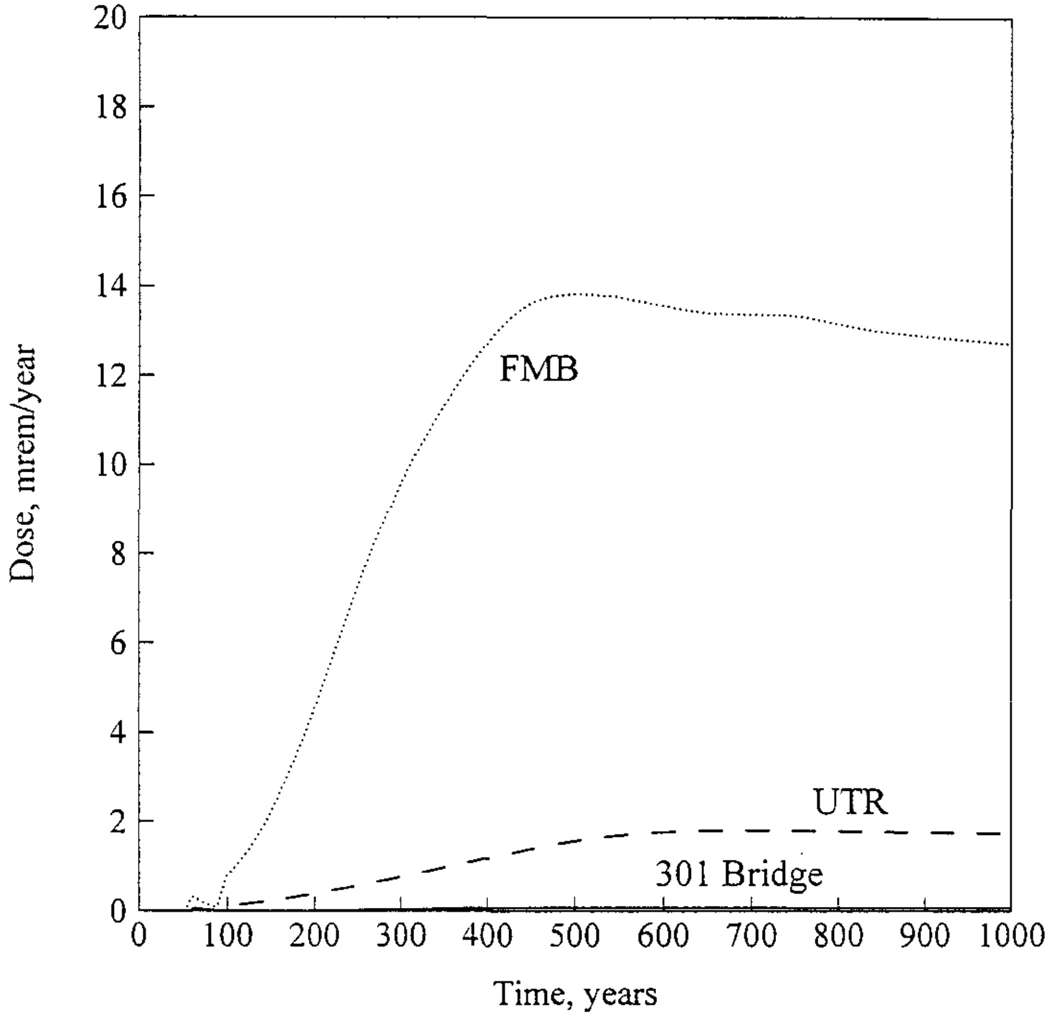

Figure 5.5-20 All pathways dose from all radionuclides combined

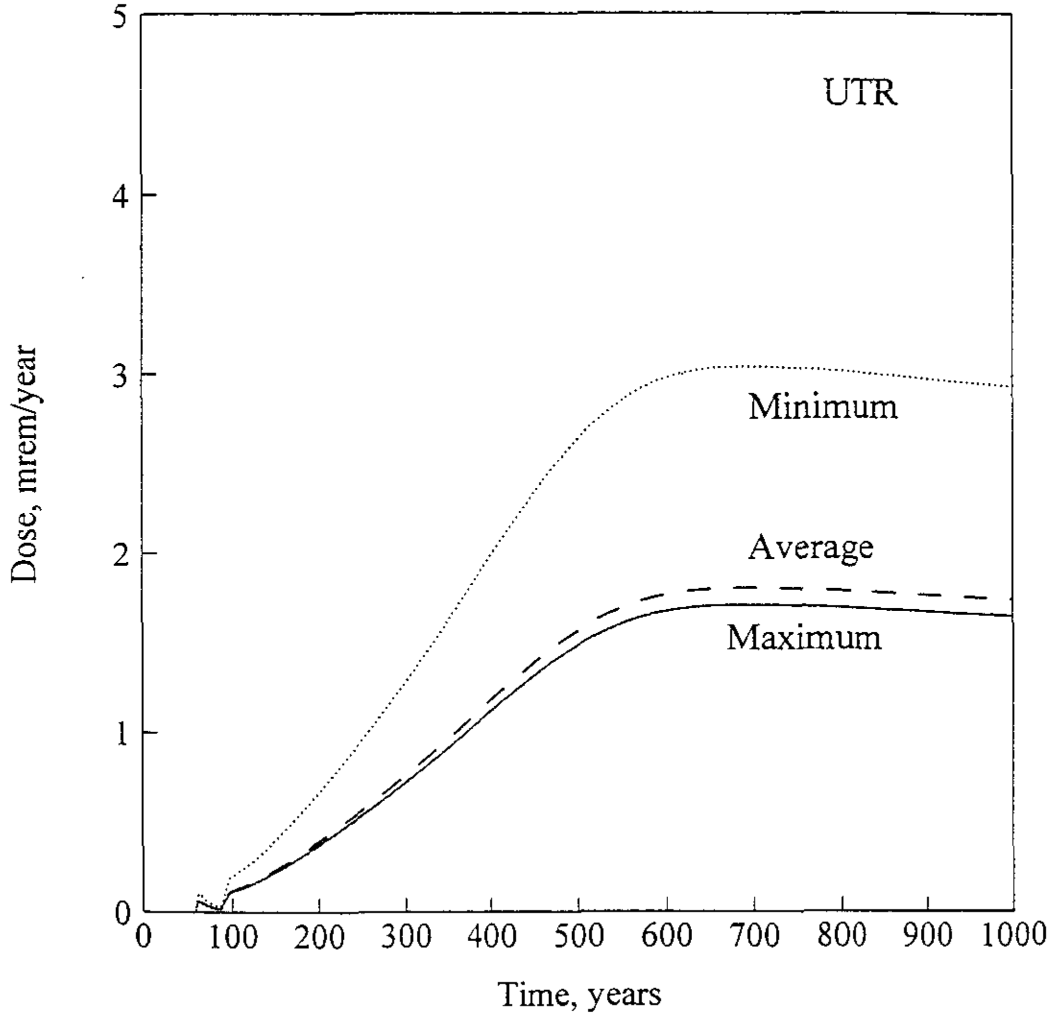

Figure 5.5-21 Effect of flow rate on dose at Upper Three Runs

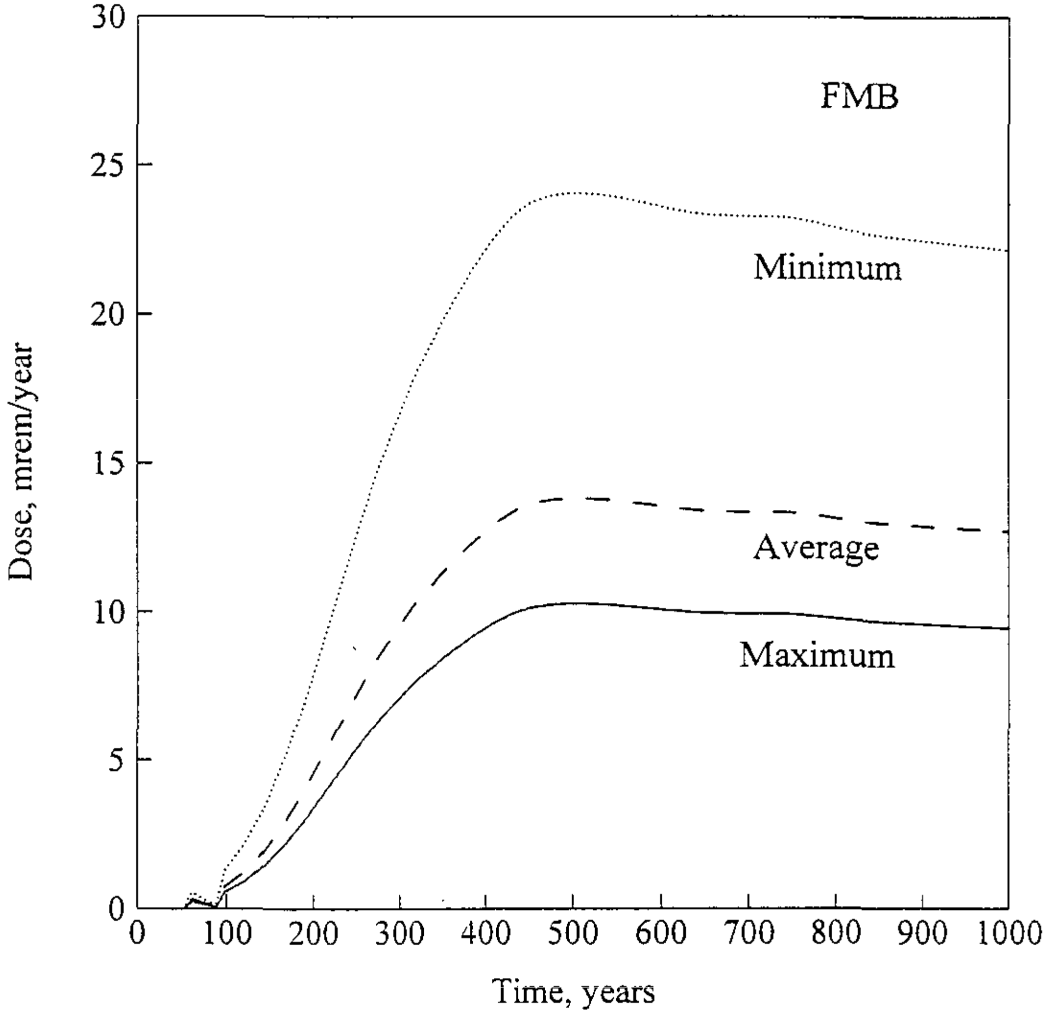

Figure 5.5-22 Effect of flow rate on dose at Fourmile Branch

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6.0 SENSITIVITY ANALYSIS

The results presented in Section 5.5 are conservative estimates derived from past and present meteorological and hydrologic conditions at the SRS. In this section, the sensitivity of these results to potential changes in selected conditions is addressed. Per DOE guidance, the sensitivity analysis has focused on the effect of land use controls.

6.1 Sensitivity to Point of Assessment

Human exposure to radionuclides released to the subsurface of the GSA may occur after radionuclides reach the nearby streams and are transported to a location of potential exposure to surface water. Current plans for future use of the SRS (Appendix A) specify that on-site streams potentially affected by GSA radionuclides (Upper Three Runs and Fourmile Branch) will be within the controlled boundaries of the site; the points of assessment were chosen outside the controlled boundaries, and thus at the mouths of these two streams and on the Savannah River (SR) rather than on the two streams at the GSA.

To understand the sensitivity of the results of this analysis to the point of assessment, doses associated with ingestion of water from Upper Three Runs (UTR) and Fourmile Branch (FMB), at the GSA, were calculated (Section 5.5). The calculated drinking water doses assume an ingestion rate of 730 L/yr, which corresponds to the rate for a maximally-exposed individual. These doses do not include recreational pathways (i.e., swimming, boating, shoreline) or the fish consumption pathway because recreation and fishing on these smaller creeks are not considered realistic activities. Average flows of these streams at the GSA are approximately 6 m^3/s for UTR and 0.4 m^3/s for FMB. These low flows are not expected to support large enough populations of fish to constitute a significant fraction of the diet of any user of the streams.

Peak doses due to consumption of water from UTR and FMB, at the GSA, summed over all radionuclides, are given in Table 6.1-1. Peak doses for principle radionuclides contributing to dose are also given in this table. These doses are dominated by ingestion of ^3H in drinking water, unlike doses calculated for exposure near the mouths of these streams (Table 5.5-2), which are dominated by ingestion of ^{14}C in aquatic foods. Total doses from ingestion of water from UTR or FMB at the GSA exceed those calculated for the stream mouths by less than a factor of two.

The results of this sensitivity analysis suggest that, while sensitive to the point of assessment, peak doses associated with subsurface radionuclides in the GSA remain below the 30 mrem/yr dose constraint and are, thus, well below the 100 mrem/yr dose limit.

Table 6.1-1 Comparison of peak doses for the maximally-exposed hypothetical individual due to drinking water from UTR and FMB at the GSA

Radionuclide(s)	Water Ingestion Dose Associated with Use of Upper Three Runs Creek at the GSA (mrem/yr)	Water Ingestion Dose Associated with Use of Fourmile Branch at the GSA (mrem/yr)
H-3	2.4	24
C-14	1.5×10^{-2}	1.8×10^{-1}
Np-237	8.7×10^{-2}	4.6
U-234	1.3×10^{-1}	1.2
U-235	4.6×10^{-3}	7.6×10^{-2}
U-236	1.8×10^{-2}	3.3×10^{-1}
U-238	1.2×10^{-1}	1.8
All Radionuclides	2.4[a]	24[a]

[a] "All Radionuclides" does not represent the addition of peak doses, because the peak doses for individual radionuclides occur at different points in time.

6.2 Sensitivity to Stream Flow

Doses calculated at the points of assessment in the mouths of UTR and FMB (Section 5.5.2) are based on the average flow of these streams. To assess the sensitivity of the results to changes in stream flow, doses were also calculated for the minimum and maximum average annual flows (Section 5.5.2). The results in Figures 5.5-21 and 5.5-22 show that doses are inversely proportional to stream flow. There is little difference between the doses calculated for the average and maximum flows because the average and maximum flows differ only slightly (for UTR, the average flow is 217 cfs and the maximum flow is 228 cfs; for FMB the average flow is 24 cfs and the maximum is 32 cfs). Doses are significantly higher for the minimum flows because the minimum flows are much lower; for UTR the minimum flow is 127 cfs, while the FMB minimum flow is 14 cfs. Calculated dose will also be inversely proportional to stream flow at other points of assessment.

6.3 Sensitivity to Use of Land not Permanently Controlled by DOE

Plans for future use of the SRS (Appendix A) propose that release of the site to the public for unrestricted use will not occur over the time period of this analysis. The GSA, which is the focus of this analysis, is located near the center of the SRS. The potentially contaminated groundwater considered in this analysis is completely captured by the surface streams which bound the GSA. Therefore, no foreseeable use of land outside the SRS boundaries is likely to alter the results presented in Section 5.

If plans for future use of the SRS were revised to allow unrestricted public use of land adjacent to the streams which bound the GSA, but not the GSA itself, it is conceivable that some use of the adjacent land could potentially affect the results of this Composite Analysis. The only alternative use of land, outside the GSA, which could affect the migration of radionuclides from sub-surface sources within the GSA to surface water is large-scale irrigation. If large volumes of groundwater are removed from the Crouch

Branch or McQueen Branch aquifers, the only aquifers capable of sustaining such volumes, the head reversal phenomenon discussed in Section 2.3.5 could be affected. If the head-reversal phenomenon were compromised, contaminants released from sources within the GSA could migrate to the deeper aquifers and, potentially, result in exposure via the groundwater pathway. However, since such large-scale irrigation is not practiced in the vicinity of SRS, this possibility was not explored further.

Other use of land outside the GSA, but adjacent to the bounding streams, could compromise the capture of groundwater by the streams that bound the GSA. For example, if the land were cleared and there were no controls to mitigate erosion, the streams could become broader and more shallow due to sediment loading. In this case, isolation of the groundwater by the streams could be compromised to some extent. The result would be that contaminated groundwater outside the GSA would become a viable pathway for exposure to the public. This possibility was not explored further here. However, if the plans for future use of the SRS were to be revised to make the land surrounding the GSA potentially available for unrestricted public use, this Composite Analysis would have to be revised to consider such a scenario.

6.4 Sensitivity to Natural Barriers

The SRS GSA has three natural barriers which are discussed in Section 2.3.5. They are the head-reversal phenomenon, the ground-water divide, and the capture of potentially contaminated groundwater by the streams (UTR and FMB) that bound the GSA. Sensitivity to the head-reversal phenomenon has been discussed in Section 6.3 above. The potential sensitivity to the groundwater divide and to the capture of groundwater is discussed in this section.

Groundwater Divide

As discussed in Section 2.3.5, only the two uppermost aquifers (Upper Three Runs aquifer and Gordon aquifer) are potentially contaminated by releases from the facilities in the GSA. The flow in the uppermost aquifer is divided within the GSA by a topographic high.

The groundwater divide lies between the OBG and the MWMF, and is defined mainly by the competing influence of UTR and FMB on the local groundwater flow patterns. The effect of the divide is to direct contaminants released from the OBG toward FMB while those released from the MWMF and the E-Area Vaults facilities are directed toward UTR.

Because the groundwater divide is largely influenced by the bounding streams, topographical changes which affect the streams will tend to affect the location of the divide. The most likely cause of such changes is closure of various facilities, particularly the OBG and the MWMF. If the divide moved toward the MWMF, more of the contaminants from the MWMF would be directed toward FMB. Alternatively, movement of the divide toward the OBG would direct contaminants from the OBG toward UTR. Such changes would not affect the calculated fluxes of radionuclides from subsurface sources to the water table. They would, however, tend to affect the migration of radionuclides within the saturated zone because the flow path to the intercepting stream would change. In the event of a shift in the groundwater divide, the summed flux of radionuclides to both streams, however, would not change significantly. An upper bound on the effect of a shift can be estimated by summing the fluxes to both streams, and calculating the dose associated with that flux for a hypothetical individual using FMB, as this stream affords the least dilution. The estimated upper bound is approximately 29 mrem/yr, which is about a 100% increase over the maximum estimated dose to a hypothetical individual in this Composite Analysis.

Groundwater Capture

As discussed in Section 2.3.5, the GSA is bounded by two surface streams, UTR and FMB which capture all the groundwater potentially contaminated by releases from facilities in the GSA. The capture of contaminants is ensured by two features of the GSA: the head-reversal phenomenon discussed in Section 6.3 and the incision of the streams through the uppermost aquifers.

Within the GSA, the Upper Three Runs aquifer is recharged by precipitation at the GSA. The Gordon aquifer is recharged both by precipitation within the GSA and by lateral flow from outside the GSA. Incision of the aquifers by the streams depends on the stream bed being at the same elevation or deeper than the uppermost portion of the incised aquifer. The relative position of the stream bed, in relation to that of the aquifer, may be altered if: 1) the depth of the stream bed is diminished, or 2) the depth of the aquifer is increased.

The depth of the stream could decrease if a large amount of sediment were to be deposited in the stream bed. This scenario is introduced in Section 6.3, but was not explored further in this sensitivity analysis. Increase in the depth of the top of the aquifers is not considered plausible. Loss of groundwater isolation via this latter route would require that the water table drop below the depth of UTR; a phenomenon that would likely only be precipitated by major climatic changes, which are not within the scope of consideration for the Composite Analysis.

6.5 Sensitivity to Source Term

An explicit analysis of the sensitivity of the results of this Composite Analysis to source term was not performed. Rather, consistent with DOE guidance, the assessment of sources other than the two LLW disposal facilities used conservative, bounding assumptions to assess the maximum potential impact of these sources.

7.0 INTERPRETATION OF RESULTS

In this section, the results of the Composite Analysis for the GSA are discussed in terms of the dose limits and constraints set forth in Sect. 2.4.3, the principal sources (facilities) contributing to dose, and the effects of sensitivities (Section 6) on these results. Consideration of the ALARA principle, as it applies to this analysis, is also given.

7.1 Comparison with Dose Limits and Constraints

The peak doses calculated to hypothetical maximally-exposed individuals within the performance time period of 1000 years are estimated to be approximately 1.8 mrem/yr at the mouth of UTR, 14 mrem/yr at the mouth of FMB and 0.1 mrem/yr at the highway 301 bridge on the SR, just downstream of the SRS (Section 5.5.2). These doses are well below the primary dose limit of 100 mrem/year established by DOE Order 5400.5 (Section 2.4.3).

In the Composite Analysis Guidance document, an additional dose constraint of 30 mrem/year is used "to ensure that no single source, practice, or pathway uses an extraordinary portion of the primary dose limit". Estimated doses in this Composite Analysis are also below this constraint. Thus an options analysis is not required.

7.2 Principal Sources Contributing to Dose

The major radionuclides contributing to dose in the Composite Analysis are ^{14}C, ^{3}H, ^{237}Np and isotopes of uranium (Section 5.5). The predominant sources of these radionuclides are the Mixed Waste Management Facility (MWMF), the Old Burial Grounds (OBG) and the high-level waste tanks as indicated in Table 4.4-5.

The active low-level waste disposal facilities addressed in the Composite Analysis, the E-Area Vault (EAV) and the Saltstone facilities, are relatively insignificant sources of these radionuclides. The saltstone wasteform and the naval reactor components disposed in the EAV resist leaching, and the vaults control infiltration of water into the wastes.

These barriers to leaching reduce and delay the release of radionuclides to the subsurface environment. Predicted releases from these facilities during the first 1000 years after disposal are therefore negligible and the doses attributable to the facilities during this time period are insignificant relative to total dose calculated for the Composite Analysis.

7.3 Effects of Sensitivities

The sensitivity analysis (Section 6) shows that the results of the Composite Analysis are most sensitive to the selection of the point of assessment. The point of assessment was derived from plans for future use of the SRS (Appendix A) which project no unrestricted use of any of the current SRS lands. Near the GSA the dose to the hypothetical maximally-exposed member of the public would approach, but not exceed the dose constraint. Given the conservatism of the current analysis, potential doses to members of the public, even on the streams at the GSA, are unlikely to exceed the dose constraint.

7.4 ALARA Considerations

The maximum peak dose of 14 mrem/yr calculated for the GSA in this analysis is considerably lower than the dose limit (100 mrem/yr) and dose constraint (30 mrem/yr). Thus, a quantitative ALARA analysis of options for reducing future doses may not be warranted. Such an assessment analyzes the cost-benefit of dose reduction; however, if the estimated cost of the analysis alone is likely to exceed the monetary equivalent of reducing the dose to zero, then the assessment is not warranted.

To determine whether a quantitative ALARA analysis is warranted, a monetary equivalence of potential dose reduction must be assigned. The DOE recommends an equivalence in the range from $1,000 to $10,000 per person-rem reduced. Thus, calculation of population doses associated with the GSA was required to make this determination.

7.4.1 Population Doses

The population doses calculated for the ALARA process in this composite analysis consider the populations served by the City of Savannah Industrial and Domestic Water Supply Plant (formerly Cherokee Hill Water Treatment Plant), near Port Wentworth, Georgia (10,000 persons), by the Beaufort-Jasper Water Treatment Plant, near Beaufort, South Carolina (60,000 persons), and the population in a 80-km (50-mile) radius of the SRS which may participate in recreational and commercial usage of the Savannah River (620,000 persons). Exposure to radionuclides of populations served by treatment plants is assumed to take place as a result of drinking water at concentrations found at the location of the plants, which are approximately 160 km downstream of the SRS. Exposure of the population in the 80-km radius is assumed to occur as a result of harvest of aquatic fish and invertebrates, and as a result of shoreline activities, swimming, and boating; ingestion of contaminated water by members of this population is assumed to be negligible. The concentration of radionuclides in river water for the 80-km radius population is assumed to be the concentration 20 km downstream of the SRS (at Highway 301) - the same location assumed for a hypothetical maximally-exposed individual (Section 5.3). The population locations and exposure routes described above are consistent with those described in the SRS Environmental Report for 1995 (WSRC 1996c).

Population doses were calculated using the LADTAP XL spreadsheet model (Hamby 1991a), described in Sections 5.4 and 5.5. Flow and exposure parameters assumed for the calculations are summarized in Table 7.4.1, and explained below.

The Beaufort-Jasper and Port Wentworth water treatment plants are the nearest such plants downstream of the SRS. The flow rate of the Savannah River at the location of these plants is assumed to be 13,000 cfs, which is the estimated average flow rate for this location (Hamby 1991b). A travel time of 4 days for radionuclides leaving the SRS before consumption is assumed, which includes transit down the Savannah River and residence in the water treatment system. Individuals in the population exposed are assumed to, on the average, consume water at a rate of 370 L/yr.

The flow rate of the Savannah River at the location of recreational usage and harvest of fish is assumed to be 10,500 cfs, which is an average for this location (Section 5.3). For the Savannah River estuary, from which saltwater invertebrates are harvested, the flow rate entering the estuary is assumed to be 11,500 cfs, which can be compared to the average rate of 13,000 cfs assumed for this estuary in the 1995 annual report (WSRC 1996). A dilution factor of three (Hamby 1991a) is assumed for the estuary, to account for the dilution of fresh Savannah River water with ocean water.

It is conservatively assumed that the population within an 80-km radius consumes the complete harvest of aquatic foods, because the potential consumption of fish (5.6×10^6 kg/yr) and of invertebrates (1.2×10^6 kg/yr) by the population based on the average individual ingestion rates of 9 kg/yr for fish and 2 kg/yr for invertebrates, exceeds the total annual harvest (approximately 3.8×10^4 kg for fish, and 3.9×10^5 kg for invertebrates). Recreational usage, in person-hours, is based on regional data obtained by Hamby (1991c).

Based on these assumptions, summarized in Table 7.4.1, doses were calculated for both populations described. The results are presented in Figure 7.4-1 in terms of person-rem per year over the time period of assessment (1000 yr). The peak dose to either population and to the aggregate of all the populations was less than 3 person-rem/yr.

7.4.2 ALARA Analysis

An ALARA analysis calculates the cost of actions that could be taken to reduce population dose versus the benefit of the dose reduction. However, when maximum individual doses are calculated to be below the 30 mrem/yr dose constraint in a composite analysis, the question becomes whether the cost of a quantitative ALARA analysis is justified.

In this Composite Analysis of the GSA, the maximum individual dose was calculated to be 14 mrem/yr for all radionuclides: well below the 30 mrem/yr dose constraint. To evaluate whether an ALARA analysis is warranted, population doses were also calculated. The maximum population dose was calculated to be approximately 3 person-rem/yr. Using the DOE's estimate of monetary equivalence for dose reduction of between $1,000 to $10,000 per person-rem potentially avoided, a maximum cost of dose reduction of $30,000 is calculated. This maximum cost is calculated assuming dose is reduced to zero, at an upper-end cost of $10,000 per person-rem and assuming a dose integration time of one year. The many conservative assumptions that went into estimation of population dose further maximizes this cost. The cost of the present analysis of the base case far exceeds this maximum cost, and thus the cost of evaluating the impact of more than one option for the GSA is expected to greatly exceed the maximum cost. The conclusion is, then, that an ALARA analysis is not warranted because of the very low population dose potentially associated with the presence of subsurface radionuclides in the GSA.

The conclusion that an ALARA analysis is not warranted is strongly influenced by the selection of the time over which population dose is integrated. DOE guidance on the dose integration time has not been issued. Due to the conservative assumptions used in this Composite Analysis, a one-year integration time was selected.

7.5 Options Analysis

The calculated doses to the hypothetical maximally-exposed member of the public of 14 mrem/yr is well below the dose constraint of 30 mrem/yr. Thus, per DOE guidance, an options analysis is not required.

7.6 Composite Analysis Maintenance

The Composite Analysis is required to be maintained, after the initial analysis is complete. Maintenance of the composite analysis requires a periodic review to ensure that the bases of the analysis remain valid. If any of the bases change significantly, the analysis must be revised and submitted to DOE for review. Based on the current analysis, only changes in the plans for future use of the SRS would be expected to increase calculated doses.

Table 7.4.1 Flow and Exposure Parameters Used in LADTAP XL for Calculating Population Doses

Parameter Description	Value used for Treatment Plant Population Doses	Value Used for 80-km Population Doses	Parameter Units
Savannah River Flow Rate	13,000	10,500	cfs
Estuary Flow Rate	na	11,500	cfs
Beaufort-Jasper Population	60,000	na	persons
Port Wentworth Population	10,000	na	persons
80-km Population	na	620,000	persons
BJ/PW Travel Time	4.0	na	d
Pop. Water Usage	370	na	L/yr
Pop. Fish Usage	na	9	kg/yr
Pop. Invertebrate Usage	na	2	kg/yr
Total 80-km Fish Consumption	na	5.6×10^6	kg/yr
Total 80-km Invertebrate Consumption	na	1.2×10^6	kg/yr
Annual Sport Fish Harvest	na	3.5×10^4	kg/yr
Annual Commercial Fish Harvest	na	2.7×10^3	kg/yr
Annual Invertebrate Harvest	na	3.9×10^5	kg/yr
Sport Fish Transport Time	na	10.0	d
Commercial/Invertebrate Transport Time	na	13.0	d
Estuary Dilution Factor	na	3	unitless
Pop. Shoreline Usage	na	9.6×10^5	person-hrs
Pop. Swimming Usage	na	1.6×10^5	person-hrs
Pop. Boating Usage	na	1.1×10^6	person-hrs

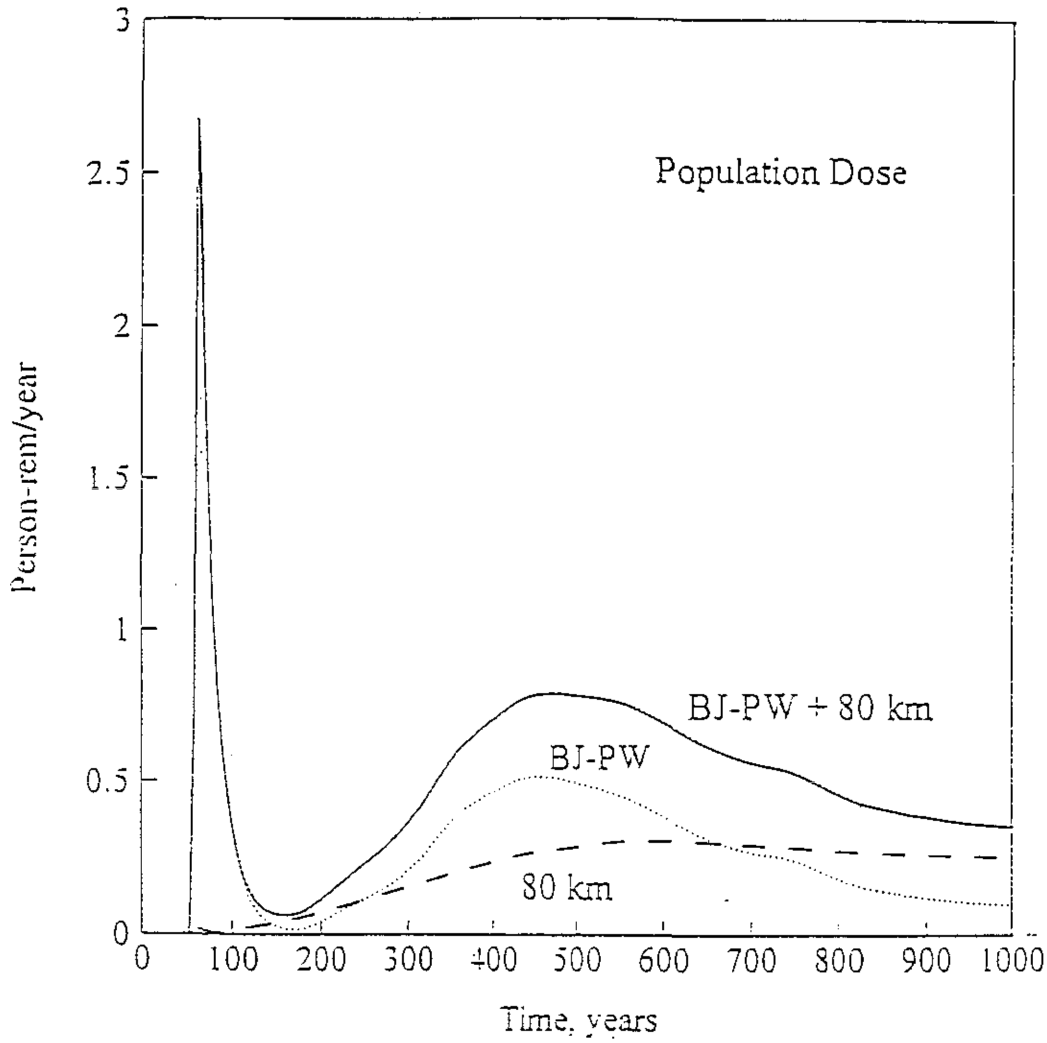

Figure 7-4.1. Collective dose to the Port Wentworth, Beaufort-Jasper and 80 km (assessed at the highway 301 bridge) populations

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ARING, BRIAN R., WSRC/AID/PMMD, Procurement Specialist

M.S. Logistics Management, Air Force Institute of Technology, Wright Patterson AFB, OH
B.S. Business, Miami University, OH

Experience: Mr. Aring has 9 years of experience at the Savannah River Site in Procurement, 6 of which have been in support of Site wide and off-Site environmental and hazardous waste studies, evaluations and assessments. He negotiated, awarded and administered contracts for environmental engineering services, Site seismic analysis and risk assessments, nondestructive testing, engineering services, and Site benefits and payroll contract transition. Mr. Aring was extensively involved as a team member in the planning and execution of two major Vendor Forums, the High Level Waste Management Forum and the Special Consolidated Solicitation Vendor Forum on Site-wide problems.

Contributions: WSRC Procurement and Contract Administrator for subcontracted work effort on the Composite Analysis program.

BUTCHER, BYRON T., WSRC/SRTC, Civil, Environmental Engineer

M.S. Environmental Engineering - University of Tennessee
B.S. Civil Engineering - University of Tennessee

Experience: Mr. Butcher is currently a manager of an applied R&D group at the Savannah River Technology Center. This group, Waste Disposal and Environmental Development, is responsible for providing technology development and applications in support of SRS waste management, environmental restoration, and decontamination and decommissioning missions. Areas of support include geochemical and groundwater modeling; radiological performance assessments and low-level waste disposal technology; hazardous and radioactive waste treatability studies; development of grout-based wasteforms and barriers; and radioactive decontamination technologies. Previous assignments at SRS have included three years each as an environmental project manager in the Environmental Restoration Department and as a solid waste technology manager (and process engineer) in the Waste Management Technology Department.

Contributions: Composite Analysis project planning and management oversight.

CARLTON, WILLIAM H., WSRC/SRTC, Health Physics

Ph.D. Biophysics - Rutgers
M.S. Physics - Emory
B.S. Physics - Emory
Certified by the American Board of Health Physics

Experience: Dr. Carlton has 16 years of academic experience at Rutgers and the Medical College of Georgia. During his 17 years at the Savannah Rive Site, he has served as a manager in Health Physics and Waste Management Operations. The last six years have been spent in Environmental Dosimetry modeling the dose from atmospheric and aqueous releases of radioactivity

Contributions: Environmental dosimetry

COOK, JAMES R., WSRC/SRTC, Geology, Geochemistry

M.S. Geochemistry - State University of New York at Binghamton
B.S. Geology - University of Arizona

Experience: Mr. Cook has 18 years of experience at the Savannah River Site, 16 of which have been in various aspects of low-level waste research. Research topics have included site selection, site characterization, site closure, and performance assessment. Mr. Cook served on the revision team for Chapter 3 of DOE Order 5820.2A and was a member of the Performance Assessment Task Team. He serves as the technical lead on the Composite Analysis advisory team.

Contributions: WSRC Technical Leader Composite Analysis team, inventory estimates and source term modeling.

FLACH, GREGORY P., WSRC/SRTC, Numerical modeling and simulation

Ph.D. Mechanical Engineering - North Carolina State University
M.M.E. Mechanical Engineering - North Carolina State University
B.S. Mechanical Engineering - University of Kentucky

Experience: Dr. Flach has 9 years of experience at the Savannah River Site focusing on numerical modeling and code development. Specific topics have included groundwater flow, solute contaminant transport, and multiphase, multicomponent reactor thermal-hydraulics. Recent efforts have involved groundwater flow modeling to optimize remediation strategies, future site characterization, and regulatory compliance boundary placement. Current research and development activities center on automating groundwater flow model development and calibration, and creating realistic heterogeneity in model hydraulic conductivity fields.

Contributions: Groundwater flow modeling.

FOWLER, JOHN R., WSRC/HLWE, Chemistry

Ph.D., University of Kansas, Inorganic Chemistry
B.A., McMurry University, Chemistry

Experience: Dr. Fowler has more than 30 years of professional experience with more than 20 years experience related to nuclear fuel reprocessing, aqueous high-level waste characterization, aqueous waste processing, and general technical oversight for regulatory compliance of radioactive waste treatment, storage and disposal. Specific experience includes collection and analysis of data on aqueous high-level nuclear wastes stored at the Savannah River Site, development of methods and processes for waste treatment, and flow sheet modeling of chemical processes for waste treatment. In his more recent role related to regulatory compliance, he provided general and technical oversight for the preparation of the Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility (SDF) at the SRS, the closure plan that was prepared for the SDF, and the projected composition, total inventory and Waste Acceptance Criteria for liquid waste used to produce Saltstone.

Contributions: Advisor to CA Team. Served as one of the principal technical reviewers for the CA report.

GOLDSTON, WELFORD T., WSRC/SWD, Senior Technical Advisor

BS Chemical Engineering - University of South Carolina
Masters in Business Administration, University of South Carolina

Experience: Mr.. Goldston has served over 20 years with SRS in various roles including technical, project management, and program management in chemical separations, high level radioactive waste management, DWPF, and low-level radioactive waste management. He has spent over 25 years in the chemical and nuclear industry in various engineering and management capacities. He has been integrally involved in the preparation of the Saltstone and E-area Vaults Radiological Performance Assessments and the startup of the Saltstone facilities. He has worked for the Dept. of Energy, Westinghouse, and is now assigned by Westinghouse to British Nuclear Fuels in the Solid Waste Dept. and is the Solid Waste Lead for the Composite Analysis.

HANE, RICHARD A., WSRC/SRTC, PHYSICS, Waste Disposal

M.S. Nuclear Engineering - University of Missouri - Columbia
M.S. Physics - University of Missouri - Columbia
B.S. Physics - Southwest Missouri State

Experience: Mr. Hane has 8 years of experience at the Savannah River Site, 6 of which have been in various aspects of radioactive waste research. Research topics have included waste characterization, transportation, packaging and disposal and impacts to performance assessments. Mr. Hane served on the revision team for WIPP requirements and was a contributor to the revision of DOE Order 5820.2A. He serves as a technical resource on the Composite Analysis advisory team.

Contributions: WSRC Composite Analysis team.

JANNIK, GERALD T., WSRC/SRTC, Environmental Health Physics

M.S. Health Physics - Georgia Institute of Technology
B.S. Mechanical Engineering - Villanova University

Experience: Mr. Jannik has 8 years of experience at the Savannah Rive Site, 7 of which have been in various aspects of Environmental Monitoring and Environmental Dosimetry. Prior to SRS, Mr. Jannik has 12 years of engineering and engineering supervisory experience, mainly in the nuclear power industry.

Contributions: Environmental dosimetry

LOWE, PAUL E., WSRC/SRTC, Quality Assurance

BS Industrial Engineering - University of Akron
Graduate Engineering studies - University of Michigan
Professional Engineer, certified auditor

Experience: Mr. Lowe has 9 years experience at SRTC which have been in various aspects of QA relating to waste isolation of High and Low level waste. He also served with Battelle Memorial Institute in site selection and characterization. Mr. Lowe has over 25 years experience in the Nuclear, Aerospace, and Commercial Industries in various engineering and management positions.

Contributions: SRTC Quality Assurance oversight, member of team

MCDOWELL-BOYER, LAURA M., ALARA ENVIRONMENTAL ANALYSIS, INC., Environmental Engineering, Health Physics

Ph.D. Civil/Environmental Engineering, University of California, Berkeley
M.S. Radiological Health Physics, Colorado State University

Experience: Dr. McDowell-Boyer has 12 years experience in radiological exposure assessment, has directed the development of a multi-media environmental transport model, studied mechanisms of subsurface contaminant migration via colloids, modeled groundwater flow and transport, and developed source terms for health risk assessments. Dr. McDowell-Boyer was the principal investigator from Oak Ridge National Laboratory on the Z-Area Performance Assessment, co-principal investigator on the E-Area Performance Assessment, and is responsible for pathway and dose analysis and technical documentation of the majority of the Composite Analysis.

Contributions: Pathway and dose analysis; documentation of the Composite Analysis.

NEWMAN, JEFFRY, WSRC/HIGH LEVEL WASTE DIVISION

M.S. Public Health - University of South Carolina
B.S. Public Administration - Kutztown University of PA

Experience: Mr. Newman has 18 years of environmental experience, seven years of which were in a large city public health department. Mr. Newman spent five years as an environmental regulator with the South Carolina Department of Health and Environmental Control. For the last six years Mr. Newman has managed various regulatory aspects of the environmental protection program for the Savannah River Site's High Level waste division. Most recently, in the capacity of environmental lead for the HLW Tank Closure Program.

Contributions: HLW regulatory advisor to the Composite Analysis team.

PULVER, ELIZABETH G., RCS CORPORATION, Technical Assistance

Associates Degree in Applied Science

Experience: Ms. Pulver has over nine years experience in the field of environmental regulatory compliance. Her work experience includes RCRA/CERCLA compliance assurance, environmental assessments and audits, and compliance inspections of hazardous and mixed waste management facilities.

REYMERS, VANESSA J., Hydrogeologist

B.S. Hydrogeology - Northern Arizona University

Experience: Ms. Reymers is working as an intern at Savannah River Site before entering graduate school to pursue a M.S. in Civil Engineering. As an undergraduate, she completed a senior thesis on the hydrological characterization of a perennial stream to provide data for an environmental restoration project.

Contributions: Assisted with subsurface flow and transport modeling.

STEVENS, WILLIAM E., WSRC/SRTC, R & D Management

M.S. Chemical Engineering
B.S. Chemical Engineering

Experience: Mr. Stevens has 21 years of industrial experience in chemical processing, waste management, and environmental restoration. His assignments include process engineering, development engineering, and management of process and project engineering groups, maintenance groups, and R & D groups. For the past eight years, he has managed an R & D organization that develops technology for support of environmental restoration and minimizing, recycling, treating, handling, and disposing of low-level radioactive, mixed, hazardous, and sanitary waste. The group has expertise in site closure, environmental transport, groundwater modeling, and decontamination. Mr. Stevens is a licensed Professional Engineer.

Contribution: Advisor to PA team.

TURNER, TIMOTHY R., CDM FEDERAL PROGRAMS CORPORATION, Environmental Engineering

B.S. Civil Engineering

Experience: Mr. Turner is a registered professional engineer and has over 6 years of experience working on environmental projects at the SRS. His work experience includes the preparation of RCRA Part B permits for several of the waste management facilities at the SRS.

Contributions: Provided technical assistance in the gathering and compiling of the residual radionuclide inventory.

WATKINS, DAVID R., CDM FEDERAL PROGRAMS CORPORATION, Data Quality Assurance

B.S. Geology

Experience: Mr. Watkins has over 10 years of experience as a professional geologist. He has served as the Quality Assurance/Quality Control (QA/QC) Coordinator for the CDM Federal Aiken, SC branch office for over five years. Mr. Watkins has received specific training as a QA/QC Coordinator and Auditor for NQA-1 projects. His work experience includes QA/QC audits and the establishment of Data Quality Objectives (DQOs).

Contributions: Quality Assurance and Data Quality Objectives.

WILHITE, ELMER L., WSRC/SRTC, Advisory Scientist

BS Chemistry, University of Missouri, Columbia, 1966.
MS Inorganic Chemistry, Washington University,St. Louis, Mo., 1969.

Experience: Mr. Wilhite has 28 years experience at the Savannah River Site. His assignments include environmental research, high-level and low-level waste research, supervision of environmental monitoring and analytical chemistry groups. Mr. Wilhite has served as a consultant to DOE Headquarters on low-level waste management for 9 years. He was the chairman of the former DOE Peer Review Panel and is the technical lead for DOE for the radiological assessments section of the response to the DNFSB recommendation 94-2.

YOUNG, KAREN E., CDM FEDERAL PROGRAMS CORPORATION, Regulatory Compliance Specialist

B.S. Environmental Resource Management

Experience: Ms. Young has over 5 years of experience as an environmental scientist with expertise in regulatory compliance. She is an expert in Resource Conservation and Recovery Act (RCRA) compliance and has assisted the Environmental Protection Agency (EPA) in developing RCRA regulations.

Contributions: Regulatory Compliance

YU, ANDREW D., ALARA ENVIRONMENTAL ANALYSIS, INC.

B.S. Chemical Engineering - National Taiwan University

Ph.D. Chemical Engineering - University of Wisconsin

Experience: Dr. Yu has 22 years of experience in subsurface flow and transport modeling. He worked 12 years in simulating enhanced oil recovery processes in the oil industry and 9 years in groundwater modeling with Savannah River Technology Center. His current interests are in performance assessment, groundwater modeling and waste disposal technology.

Contributions: Performed subsurface flow and transport modeling.

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United States Government Appendix A **Department of Energy (DOE)**

memorandum

Savannah River Operations Office (SR)

DATE: JAN 29 1996

REPLY TO ATTN OF: E&PSD (Druelle, 803-952-7125)

SUBJECT: SRS Future Use Project Report (Reference: Transmittal of Final Draft "Forging the Missing Link: A Resource Document for Identifying Future Use Options," Grumbly/Pearman letter, 1-12-94,)

TO: Thomas P. Grumbly, Assistant Secretary for Environmental Management (EM-1), HQ
Donald W. Pearman, Associate Deputy Secretary for Field Management (FM-1), HQ

In response to your letter, attached is the "SRS Future Project Report." This report contains the interested internal and external stakeholders' preferred use recommendations. In addition, I have attached SR's map showing the Site as a National Environmental Research Park (NERP) which reflects the known future uses of the Site. This map is SRS's Future Use map.

The recommendations contained in the report are as follows:

1. SRS boundaries should remain unchanged and the land should remain under the ownership of the Federal Government, consistent with the Site's designation as the first NERP.
2. Residential uses of SRS land should be prohibited.
3. If DOE or the Federal Government should ever decide to sell any of the SRS land, then DOE shall seek legislation to permit former landowners (as of 1950-52) and/or their descendants to have the first option to buy back the land they once owned.
4. All SRS land should be available for multiple use, except for residential use, (e.g., industry, ecological research, natural resource management, research and technology demonstration, recreation, and public education) wherever appropriate and non-conflicting.
5. Some of the land should continue to be available for nuclear and non-nuclear industrial uses and commercial industrialization should be pursued.
6. Industrial and environmental research and technology development and transfer should be expanded.
7. Natural resource management should be pursued wherever possible with biodiversity being the primary goal.
8. Recreational opportunities should be increased as appropriate.
9. Future use planning should consider the full range of worker, public, and environmental risks, benefits, and cost associated with remediation.

The report recommendations are a reflection of the desires of the great majority of our approximately 350 stakeholders who participated in the process. The report contains all of the options/opinions received. Where we have not adopted specific recommendations, we have addressed them. The report recommendations are derived from common themes that emerged during the process and are consistent with the consensus recommendations made by the SRS Citizens Advisory Board (CAB). In addition, the CAB agrees that the recommendations of this report meets the intent of their recommendations. Action is underway to implement the report's recommendations. This report will be used in the Site's future long-term planning process and will be considered in our decisions.

This report culminates a major effort over the past two years for both SRS staff and external interested stakeholders, and is the result of that effort to integrate the widely diverse options/opinions into recommendations.

If you have any questions on this report, please contact Don Druelle at 803-952-7125.

Mario P. Fiori
Manager

E&PSD:DOD:cll

EB-96-015

2 Attachments
1. SRS Future Use Project Report
2. SRS's Future Use Map

U.S. Department of Energy
Savannah River Operations Office

Savannah River Site
Future Use Project Report

Stakeholder Recommendations for SRS Land and Facilities

January 1996

SAVANNAH RIVER SITE
FUTURE USE PROJECT REPORT

Stakeholder-Preferred Recommendations for SRS Land and Facilities

Final

January 1996

UNCLASSIFIED

Don Druelle 1/29/96
Don Druelle, Future Use Project Leader

Does not Contain Unclassified Controlled Nuclear Information
ADC & Reviewing Official
____
Manager, Integrated Site and System Planning Section
Date 1/29/96

Table of Contents

Executive Summary

For nearly 40 years, the Department of Energy and its predecessor agencies produced nuclear materials for the nation's defense programs at the Savannah River Site. Today, the focus of the Department has shifted to waste management and environmental remediation. Decisions and planning for managing these activities will depend on the future use of the land and facilities at SRS. This document summarizes the findings of the SRS Future Use Project and provides recommendations to the Department of Energy to aid in those future decisions.

In January 1994, DOE directed each site to develop stakeholder-preferred future use options by the end of 1995. The Savannah River Operations Office initiated the SRS Future Use Project in the spring of 1994. Because the future use of SRS will affect a wide diversity of stakeholders, a variety of public involvement approaches was used to reach them.

In the initial SRS Future Use Project public meetings, stakeholders expressed a preference that the report be a summary of the comments received as many individuals wanted the opportunity to provide input into the process independently. While there was no general consensus reached, several common themes emerged during the Future Use Project. These themes, recognized by the Savannah River Future Use Project Team as recommendations, are summarized in the following vision, and are listed as recommendations below.

Vision

The Savannah River Site should remain a national asset. It must be maintained and improved to meet governmental needs for both its historical defense capabilities and new nuclear and non-nuclear missions, and support commercial industrial initiatives that enhance the local and national economy. Of equal importance, as the first and most diverse National Environmental Research Park, the site must sustain and expand its internationally recognized ecological and environmental restoration research and maintain and improve its natural environment. These two interrelated concepts will ensure that new missions, industrial activities, remediation, research, educational programs and recreational opportunities are pursed in harmony.

Recommendations

- *SRS boundaries should remain unchanged, and the land should remain under the ownership of the federal government, consistent with the site's designation as the first National Environmental Research Park.*

- *Residential uses of SRS land should be prohibited.*

- *If DOE or the federal government should ever decide to sell any of the SRS land, then DOE shall seek legislation to permit former landowners (as of 1950-52) and/or their descendants to have the first option to buy back the land they once owned.*

- *All SRS land should be available for multiple use, except for residential use, (e.g., industry, ecological research, natural resource management , research and technology demonstration, recreation, and public education) wherever appropriate and non-conflicting.*

- *Some of the land should continue to be available for nuclear and non-nuclear industrial uses, and commercial industrialization should be pursued.*
- *Industrial and environmental research and technology development and transfer should be expanded.*
- *Natural resource management should be pursued wherever possible with biodiversity being the primary goal.*
- *Recreational opportunities should be increased as appropriate.*
- *Future use planning should consider the full range of worker, public, and environmental risks, benefits, and costs associated with remediation.*

These stakeholder-preferred recommendations and map will be considered by the Department throughout future planning and decision-making activities as it weighs mission needs, technical capabilities, legal requirements, and funding.

1.0 Overview of the Savannah River Site Future Use Project

1.1 Introduction and Objectives

In January 1994, the Department of Energy (DOE) initiated a complex-wide process to seek internal and external stakeholders' recommendations on the future uses of the land and facilities at each of the DOE sites. Each field office was to obtain its stakeholder-preferred future use recommendations independently using methodologies suited best to its stakeholders. *Forging the Missing Link: A Resource Document for Identifying Future Use Options* provided guidance for the process.

The purpose of this *SRS Future Use Project Report* is to summarize Savannah River Site (SRS) stakeholder-preferred future use recommendations, to explain the process used to obtain those recommendations, and to provide these recommendations for the Department to use in its decision-making activities. These stakeholder-preferred recommendations will be considered by the Department as it weighs ongoing and future mission needs, technical capabilities, legal requirements, and funding throughout future planning and decision-making activities. These activities include strategic planning, comprehensive planning, siting new facilities, decommissioning surplus facilities, environmental research, and remediation decision-making. All planning and future use decisions will require additional public input and these recommendations will change as missions and requirements evolve.

1.2 Stakeholder Recommendations for Future Uses

In the initial SRS Future Use Project public meetings, stakeholders expressed a preference that the report be a summary of the comments received, as many individuals wanted the opportunity to provide input into the process independently. With few exceptions the comments fit several common themes. These themes, constituting the recommendations, and a brief summary of stakeholder comments are shown below.

- *SRS boundaries should remain unchanged, and the land should remain under the ownership of the federal government, consistent with the site's designation as the first National Environmental Research Park.*

  Comments addressed concerns ranging from maintaining federal ownership within existing boundaries to returning land to counties or private individuals. Most participating stakeholders expressed a desire to keep the existing SRS boundaries intact for security and safety concerns. Many consider SRS to be a national asset and were concerned about future national needs for the land. Others expressed a concern that if this land were sold or given away, the government could never acquire this land again. In addition, many wanted SRS to continue its environmental research and recognized a need to isolate the site for this purpose, consistent with its current designation as a National Environmental Research Park (NERP). As a NERP, SRS is a field laboratory, dedicated to ecological research with studies of environmental impacts of site operations and public education. The Department is supporting Congressional legislation that would formalize the Atomic Energy Commission's designation of the site as the first NERP. The Department also has an ongoing effort to encourage private operation of many site facilities. These activities are currently performed through lease agreements. The SRS Citizens

Advisory Board (CAB) also commented that the fair market value of the land is less than estimated cost of remediation.

- *Residential uses of SRS land should be prohibited.*

  Although suggestions were made to reserve land for prisons or shelters for homeless families and individuals, most did not advocate general residential use. Current and proposed future missions for the site preclude any residential use. Previous comments addressing keeping the site boundaries intact also apply to this section.

- *If DOE or the federal government should ever decide to sell any of the SRS land, then DOE shall seek legislation to permit former landowners (as of 1950-52) and/or their descendants to have the first option to buy back the land they once owned.*

  Several former landowners expressed an interest in having their land returned to them. Many have strong ties to the land as some of the families had lived on this land for two or three centuries before 1951. They requested the return of the land they once owned either for personal use or to profit from any future economic development. These citizens believed they had done their patriotic duty in the 1950s but wanted the opportunity to buy their formerly owned land if the Department ever decided to sell this land. Most former landowners who participated suggested that they be given the right of first opportunity to buy this land if it is ever to be sold. However, under current regulations, the federal government cannot give or sell excess property preferentially. All surplus property, including land, must be excessed to the General Services Administration which has specific requirements for disposition of this excessed property.

- *All SRS land should be available for multiple use, except for residential use, (e.g., industry, ecological research, natural resource management, research and technology demonstration, recreation, and public education) wherever appropriate and non-conflicting.*

  Comments on multiple land uses ranged from industrial, recreational, ecological/natural resource management to no use. Since its inception, SRS has accommodated multiple uses on most of its land area. Many stakeholders are interested in continuing, if not expanding, this multiple use concept. Various members of the public mentioned the site's status as the first National Environmental Research Park and expressed a desire to continue or expand the opportunities that designation offers including co-locating industrial, ecological, resource management, and recreational activities within limitations of health, safety, and security.

Some of the land should continue to be available for nuclear and non-nuclear industrial uses, and commercial industrialization should be pursued.

Comments on industrial uses for the site ranged from seeking new nuclear and non-nuclear missions (private and government); continuing new missions; increasing industrial and environmental research, development, and technology transfer to completing current missions and closing the site. Some wanted current operations terminated and the site permanently closed, but DOE is required to continue ongoing defense and environmental management missions to ensure national security and safe handling of the legacy of defense production. In an effort to offset the economic impact of declining defense activities, DOE and its contractor, with community involvement and support, is actively pursuing industrial diversification and privatization both on and off site.

- *Industrial and environmental research and technology development and transfer should be expanded.*

  Comments included using the site for broad research and development applications such as nuclear, non-nuclear, light industrial, waste, storage and treatment, bioremediation, aquaculture, forest products, anti-matter energy sources, transportation, recycling, medical, and renewable energy. In addition, many comments addressed the site's status as a National Environmental Research Park where contaminated sites could be used in the development and demonstration of technology and where long-term environmental studies are secure from outside interference.

- *Natural resource management should be pursued wherever possible with biodiversity being the primary goal.*

  Comments ranged from expanding current forest management activities to introducing indigenous species to allow natural restoration, to assuring no loss of wetlands.

- *Recreational opportunities should be increased as appropriate.*

  Predominant preference of stakeholder participants was to expand current recreational uses (hunting and walking) and allow additional recreational activities as deemed appropriate. These include fishing, biking, bird watching, bird hunting, boating, camping, canoeing, photography, off-the-road driving, etc.

- *Future use planning should consider the full range of worker, public, and environmental risks, benefits, and costs associated with remediation.*

  Commenters expressed a broad range of concerns related to the level of risk, benefits, and costs which should be evaluated before decisions are made. Concerns addressed both onsite and offsite potential impacts. Most expressed the desire that the health and safety of workers, the public and the environment be the primary consideration in planning the future of SRS. However, they also advocated increased consideration of risks, benefits, and costs associated with future site activities. This was particularly true where future remediation activities were concerned. In addition, many endorsed continuing and expanding ongoing studies of ecological and human health.

1.3 Process To Identify Future Use Options

From the beginning, the SRS Future Use Project Team sought stakeholder input on the processes to be used in obtaining and reporting their input. (See Appendix E for a list of the team members.) Based on that input, SRS used a variety of public participation activities to share information and obtain stakeholder-preferred future use recommendations. These activities included public meetings, presentations to civic and community organizations, briefings for elected officials, and working with interested citizen groups as shown in Appendix F, *Organizations*. A prepared script was used to ensure consistency in presentation of information to all stakeholders.

Throughout the process, many forms of information were made available for interested stakeholders. Some information was mailed to all interested stakeholders; other information was available to those who requested it; and specific contacts were named to provide answers to any questions. A database of the names and addresses of interested stakeholders was created, eventually numbering more than 300. Types of information mailed to all interested stakeholders included meeting notes from all public meetings, meeting notices for upcoming meetings, and the *SRS Future Use Project Public Participation Plan*. In addition, other documents including the *Savannah River Operations Office Strategic Plan* and the *Land Use Baseline* Report were mailed to individuals upon request. A folder of information about the Future Use Project was also available at public meetings and was also mailed to anyone who had general questions about the Future Use Project. The folder included a list of related documents available; fact sheets about key SRS activities; and the names, addresses, and phone numbers of contacts for additional information. A toll-free telephone number was made available to facilitate the process with stakeholders.

1.3.1 SRS Future Use Project Public Participation Plan

As the initial step in developing this report, the Future Use Project's first public meeting focused on the development of a public participation plan. At that meeting, a workshop held in Aiken in September 1994, citizens discussed what process(es) should be used to identify stakeholder-preferred future use options and what type(s) of public participation approaches would best meet their needs. Also, stakeholders were provided a copy of the *Draft Land Use Baseline Report* for review and comment and to provide education on current site uses.

Those who attended that meeting suggested that SRS staff provide a "strawman" of the public participation planning process, based on the input received from the workshop. Some believed that the SRS Citizens Advisory Board (CAB) should be the primary focus for stakeholder involvement so that a consensus of stakeholder-preferred future use recommendations could be developed. Others wanted an open forum in which they could provide their individual preferences directly to DOE. Many suggested that regulatory agencies' involvement, i.e., South Carolina Department of Health and Environmental Control (SCDHEC) and Environmental Protection Agency (EPA), was critical for the success of this project.

In January 1995, a draft public participation plan for the project was sent to interested individuals and groups for comment. The draft plan contained a strategy that included public meetings or workshops and a survey of community leaders. At the Augusta public meeting in February 1995, held to collect comments on the draft plan, questions were raised about the use of surveys as a technique. As a result of these comments, the survey was dropped from the process. The public participation plan for the Future Use Project was finalized and mailed to interested stakeholders.

Also at the February meeting, concerns were raised that DOE had not reached the economically disadvantaged communities and people of color in the past and needed to focus its efforts to involve these stakeholders. While the draft *SRS Future Use Public Participation Plan* reflected a commitment to reach those communities, additional efforts were made to include those interested communities by identifying and contacting organizations which had not previously expressed interest or attended a Future Use Project meeting.

1.3.2 Public Meetings and Feedback

During the Future Use Project process, six public meetings, as shown in Figure 1, were held in South Carolina and Georgia. (See Appendix G for complete summaries for each public meeting.)

Numerous organizations were invited to co-host these public meetings. After the first meeting, all meetings were co-sponsored by the Department and the SRS CAB Subcommittee on Risk Management and Future Use. The second meeting, held in North Augusta, was also sponsored by the Savannah River Regional Diversification Initiative. Co-sponsorship streamlined the process; lowered costs; assured that all parties shared information; reduced the burden on stakeholders; and provided stakeholder groups the opportunity to take a more active, visible role.

At the November 1994 meeting, held in North Augusta, the *Draft Land Use Baseline Report* was presented to stakeholders for information, review, and comment. This report was developed to provide a simple and easy-to-read narrative and map display of information related to current SRS land uses. The *Savannah River Operations Office Strategic Plan* was also presented. The *Strategic Plan*, developed by the DOE employee stakeholders, describes DOE missions and outlines the employees' vision of future programs and activities, interactions with regional partners, and commitment to worker and public safety. Six business lines—Industrial Competitiveness, Energy Resources, Science and Technology, National Security, Environmental Quality, and Infrastructure—are integral to the plan and were discussed in the context of future use.

Also at this November meeting, participants "brainstormed" ideas on possible future uses for the land and facilities at SRS. Various groups suggested many industrial and/or commercial uses and encouraged the Department to have an open process.

Additional public meetings were held in Barnwell, and Beaufort, South Carolina, and Augusta, and Savannah, Georgia, to accept comments on the public participation plan and solicit recommendations for stakeholder-preferred future uses.

During the spring and summer of 1995, several presentations about the Future Use Project were given to civic clubs and community organizations including the Savannah River Regional Diversification Initiative, Lions' Clubs, Ellenton Reunion, Augusta Sierra Club, Aiken Chapter of the NAACP, and African-American representatives and other citizen groups. (See Appendix F for complete list of organizations.) A prepared script was used at these meetings so that all participants in the Future Use Project process would receive the same information. These groups were interested in the Future Use Project, but other than the former landowners at the Ellenton Reunion and the Citizens for Environmental Justice, these civic clubs and groups did not formally express any additional recommendations for the Future Use Project. Many attendees of the Ellenton Reunion expressed the desire they should have first right of refusal to buy land formerly owned, if the land was proposed for sale. Offers were made to brief elected officials, and on request, a briefing was given to a staff member for U. S. Representative Charles Norwood (R-GA).

Date	Location	Purpose
September 19, 1994	Aiken, SC	Discuss the public participation process
November 1, 1994	North Augusta, SC	Review the *DOE-SR Strategic Plan* and *Land-Use Baseline Report*
February 2, 1995	Augusta, GA	Solicit comments on the draft Future Use Public Participation Plan
April 11, 1995	Barnwell, SC	Solicit recommendations for future uses
May 3, 1995	Beaufort, SC	Solicit recommendations for future uses
May 4, 1995	Savannah, GA	Solicit recommendations for future uses

Figure 1-Future Use Project Public Meetings

1.3.3 Other Stakeholder Groups

The SRS Citizens Advisory Board (CAB) formed the Subcommittee on Risk Management and Future Use in June 1994 in response to the Department's Future Use Project initiative. This subcommittee, composed of CAB members and other stakeholders, met on a regular basis to develop their recommendation for the full CAB. At its September 1995 meeting the full CAB unanimously approved a recommendation to DOE. (See Section 2.1.1, *SRS Citizens Advisory Board Recommendation* and Appendix B, *Citizens Advisory Board Recommendation.*)

In response to stakeholder comments and the Department's environmental justice policy, specific attention was given to the economically disadvantaged communities surrounding SRS. A briefing was given to the Aiken Chapter of the National Association for the Advancement of Colored People (NAACP) to determine their level of interest in the Future Use Project. In addition, a Future Use Project team member also met with representatives of several African-American communities to determine the level of interest in this project from residents in the Augusta, Georgia, region.

The Department of Energy also held a public meeting in Savannah in May targeting minority groups. The meeting date, time, place, and advertising were coordinated with Citizens for Environmental Justice, a minority-focused community group in Savannah, Georgia. In addition, the Future Use Project was the topic for discussion at a workshop sponsored by Citizens for Environmental Justice held in September. The summary of recommendations from this group can be found in Section 2.1.2, *Summary of Citizens for Environmental Justice Recommendations* and the full list of recommendations can be found in Appendix C, *Citizens for Environmental Justice Recommendations.*

A group of site employees, the Land Use Technical Committee, also provided their input into the Future Use Project. These internal stakeholders are 23 senior technical experts from all the major site organizations (Savannah River Ecology Laboratory, Savannah River Forest Station, Westinghouse Savannah River Company, etc.) representing all major program areas. A summary of their recommendations is shown in Section 2.1.3, *Summary of SRS Land Use Technical Committee Recommendations* and additional information is in Appendix D, *SRS Land Use Technical Committee Recommendations*.

2.0 Stakeholder Preferences For Future Use

This section provides a summary of recommendations from the SRS Citizens Advisory Board, Citizens for Environmental Justice, the SRS Land Use Technical Committee, and comments received at public meetings and by the mail by interested stakeholders. The additional information about these recommendations can be found in the appendices. These recommendations are shown here in no particular order of importance and all comments were considered equally.

2.1 SRS Citizens Advisory Board Recommendation

The recommendation and the Vision, a supplemental document, are shown in Appendix B, *Citizens Advisory Board Recommendation*. The map, shown on the following page is part of the recommendation passed by the Citizens Advisory Board in September 1995.

(1) SRS boundaries shall remain unchanged and the land shall remain under the ownership of the federal government; national security shall not be compromised. Private use of the land will be implemented by lease agreements.

- Unforeseen national needs may occur
- Fair market value of the land is less than estimated cost of remediation

(2) Multiple uses (excluding residential) shall be considered for individual SRS zones. Land use planning shall be directed toward subdivision of the site into nuclear (defense and commercial), non-nuclear, and environmentally protected sectors. Industrial development may only be located in defined industrial zones.

- Currently many land areas have several non-conflicting uses
- Small areas can be dedicated to specific use
- Examples of concurrent multiple uses include environmental remediation research, ecological research, recreational, ecological preserves, and education and research areas

(3) Residential uses of SRS land are to be prohibited.

- Liability concerns and public perceptions of risk would make it difficult to market SRS land
- Residential development is not consistent with meeting goal of unforeseen national needs

(4) Future use planning shall consider the full range of worker, public and environmental risks, benefits and costs.

- Risks, costs, and resulting benefits must be studied before decisions are made
- Risks inherent in remediation must be considered (Example: transportation)
- Public wants to see appreciable benefits and risk reduction for costs of remediation
- Studies of human and ecological health must continue

(5) Commercial industrialization of industrial zones (about 1/3 of the land) shall be actively pursued. Within

industrial zones the land is available for multiple use and non-conflicting multiple uses may continue after a site is industrialized.

- To ensure viability of local region, additional industrialization is needed
- Opportunity to demonstrate how well industry can be integrated with environmental park
- Future industrial siting should consider use of adjacent land and incorporate an appropriate buffer
- Industrial development should be encouraged
- Industrial sites include current industrial uses and groundwater plumes and 1000-foot buffer
- Industrial cleanup standards should be applied to industrial areas

(6) Research and technology demonstration activities shall be actively pursued.

- SRS was first NERP, as such it is a major center for ecological and radioecological research
- Areas of contamination can provide opportunities for field testing of new cleanup technologies
- Opportunities for public education on industrial/ecological interactions should be expanded
- Land use controls and security systems are important to researchers
- SRS should continue a strong technology transfer program

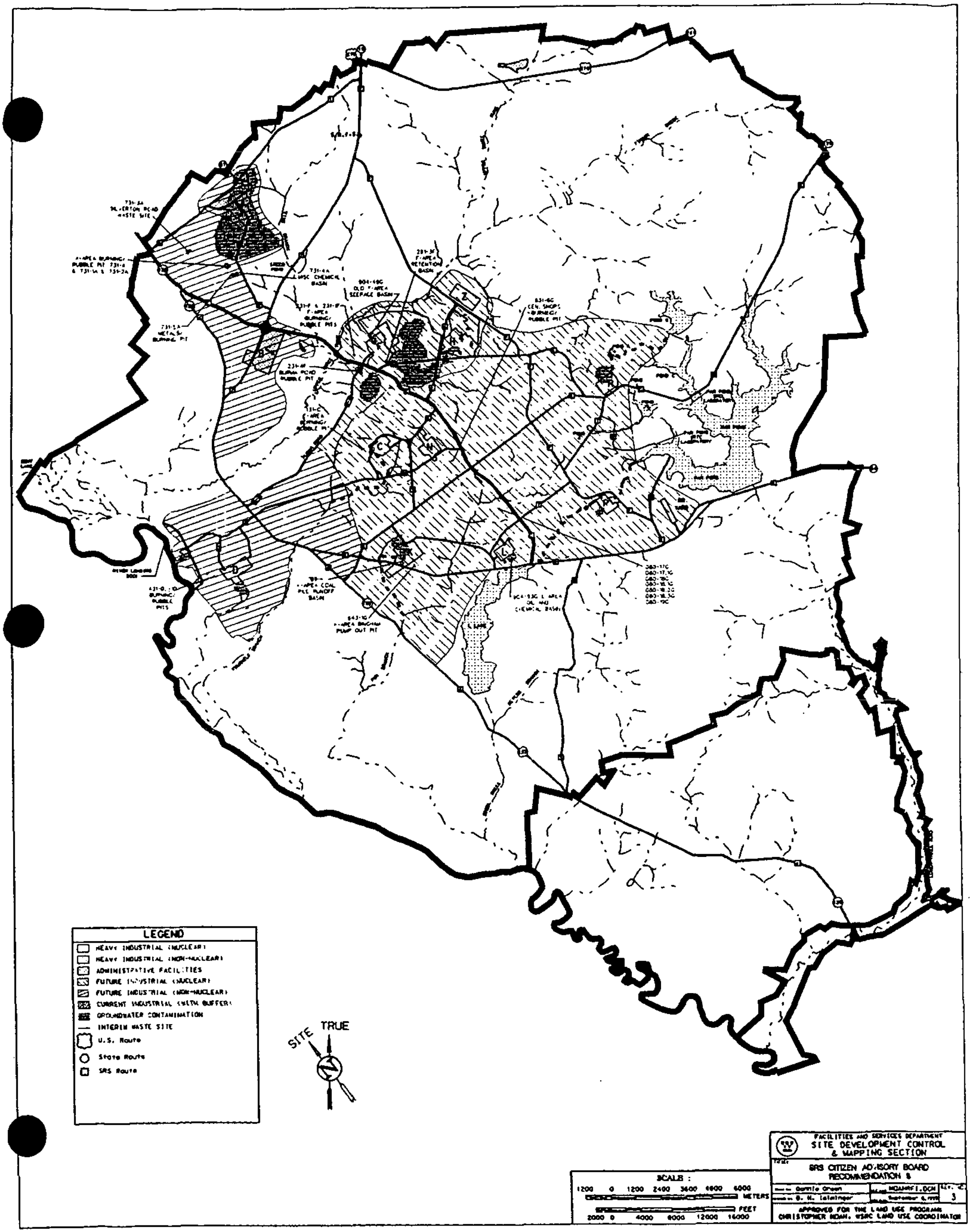
(7) Natural resource management activities in non-nuclear and non-industrial zones shall actively pursue biodiversity.

- Biological diversity shall be encouraged on SRS lands with special emphasis on non-industrial areas.

(8) Increased recreational opportunities shall be actively promoted (with appropriate controls and/or restrictions).

- Current recreational activities can and should be expanded
- Other recreational activities should be considered with appropriate restrictions

(9) Should the federal government decide to sell any of the SRS land, then former landowners (as of 1950-52) and/or their descendants shall have first option to buy back their formerly owned land for uses consistent with land use zones and appropriate standards.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FACILITIES AND SERVICES DEPARTMENT
SITE DEVELOPMENT CONTROL
& MAPPING SECTION
SRS CITIZEN ADVISORY BOARD
RECOMMENDATION 8
APPROVED FOR THE LAND USE PROGRAM
CHRISTOPHER NOAH, WSRC LAND USE COORDINATOR

2.2 *Summary of Citizens for Environmental Justice Recommendation*

The complete recommendation can be found Appendix C, *Citizens for Environmental Justice Recommendation.*

Overall Summary

It was strongly urged and reiterated that the Savannah River Site's land be used for a cemetery only, because of the level of contamination it should and could not be used for any other reasons.

Overall Recommendations

- It was suggested that the land never be used for inhabitation by stakeholders.
- Only trained personnel should be allowed to work and inhabit the land.
- Continued research on the site was also recommended.

Community Perspective

Overall, the community exhibited distrust with the whole idea of any future use of land masses that are so thoroughly contaminated with all major categories of highly radioactive nuclear waste along with tons of contaminated equipment, supplies, and clothing. There was agreement that the site should be cleaned up to the highest possible standard that technology will accommodate. The development of newer, more efficient, and more scientifically sound technology was encouraged.

Scientific Recommendations

- Initiate biological research that use microorganisms to breakdown nuclear radioactive waste that in the process reduces the level of radioactivity.
- Incorporate pollution prevention into all clean-up activities to stop further nuclear contamination.

2.3 *SRS Land Use Technical Committee's Future Use Recommendations*

These recommendations provide the conceptual design of the future use of the Savannah River Site, as envisioned by the internal stakeholders represented by the site's Land Use Technical Committee (LUTC). These recommendations can serve as a guide for program planning, facility siting, and waste site remediation. Both the opportunities and the limitations of SRS land and existing facilities, as well as regional economic development goals, have been considered in arriving at recommended primary future use and ancillary activities. While many future "uses" are envisioned for the site, a "primary use" has been recommended to meet the requirements of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). Compatible land-use activities also were listed to illustrate that the "multiple land use" concept should continue to be employed at SRS. The LUTC recommends that the primary future use be industrial and that primary supporting activities be consistent with the site's designation as a National Environmental Research Park (NERP).

These recommendations were compiled by the LUTC, which is a comprised of 23 senior technical experts from all major site organizations who supply in-depth technical land-use technical analysis to site management regarding project siting, land-use conflict resolution and planning, and CERCLA and RCRA compliance.

Recommendation One - Continue federal ownership, with industrial uses as primary

The LUTC proposes that the site remain under federal control and that industrial uses continue as in the past, with emphasis on stabilization activities of surplus materials and facilities. However, the percentages of land used for particular activities may change (current percentages are 15 percent developed and 83 percent undeveloped). Except for inquiries from former site residents, there appears to be no public demand for SRS land. Although contaminated areas and waste sites do not present an immediate threat to public and environmental health, the contamination is dispersed across much of the site, thus rendering most areas of the site incompatible with public transference. Additionally, regulators have indicated they would oppose any move to release land that had not been cleaned up to residential standards. SRS has demonstrated that many diverse activities can coexist. Eliminating federal ownership would significantly affect these relationships and eliminate some of them altogether. Also, the number, time frame, complexity, and costs of required studies would be major impediments to an SRS real estate turnover.

Recommendation Two - Increase environmental/geological research

SRS leads the DOE complex in many areas: established as the first NERP in 1972; known as a leader in environmental remediation technologies; and seen as a treasure trove of cultural information. The unique research conducted by the Savannah River Forest Station (SRFS) and the reputations of the Savannah River Ecology Laboratory (SREL), and Savannah River Technology Center, and the Savannah River Archaeological Research Program (SRARP) contribute to the viability of potential future uses for SRS. Researchers have indicated that foundation, university, and government funding support would be forthcoming with a more stabilized planning base. The research and technology application also could expand to unexploited areas of study, such as algaculture, aquaculture, and medicine—and could broaden current programs in

- bioremediation
- forest products
- the fate and effects of contaminants in the environment
- archaeology and cultural anthropology

Recommendation Three - Designate no area as residential

A number of reasons preclude "residential" designation for SRS. First is contamination. While the most dangerous contamination is contained and is not a health hazard, remediation cannot be accomplished in some site areas—mostly water bodies—with today's technology. While most site land is free of contamination, future residences could be located near water bodies, which may present a risk, albeit, remote, to full-time residents. For protection, each water body would have to be fenced and patrolled, and such restrictions would create an unacceptable, checkerboard pattern of land use. Also, many research projects, technology demonstrations, meteorological towers, and monitoring devices would have to be relocated or eliminated. Finally, federal liability has not been determined. With controlled access, the government can be reasonably assured that the public and site employees will not be exposed to undue risks. With unrestricted public access, however, government liability would need to be determined. Thus, the government should maintain ownership responsibility and ultimate oversight of SRS.

Recommendation Four - Consider remediation risks and costs

Because of SRS's mix of contamination and the constraints surrounding remediation program budgets, there are limits on how much of the site can reasonably be remediated to regulation-acceptable levels. Therefore, efforts should concentrate on containment and monitoring to protect public health and the environment and on the cleanup of areas that may limit future land-use activities.

Recommendation Five - Maintain/increase natural resource management

Natural resource management activities play a significant role at SRS. Increases in these activities could enhance other future uses. For example, using the present acreage of forested lands and the concept of multiple-use management, additional opportunities can be created for recreation, education, and research. According to the Water Branch of Georgia's Environmental Protection Division, very little assimilative capacity is left in the Savannah River because of waste dumping by industries and municipalities. Consequently, keeping large areas such as SRS along the river in a relatively natural state would preserve the site's environmental integrity and promote offsite river development.

Recommendation Six - Maintain cultural resource compliance

The Savannah River Archaeological Research Program's primary purpose is to provide DOE-SR with recommendations about cultural resource management to ensure that DOE remains in compliance with federal laws and regulations. Because proper management of these resources depends on assessment of archaeological site significance, SRARP began a phased approach to compliance in 1973 with a program of reconnaissance, watershed, and project-specific surveys and of excavation. This program, conducted in conjunction with major land users, helps identify and preserve SRS cultural resources. Cultural research provides background data for former landowners and Native American constituencies and assists local planners. Resource management activities should continue to focus on 1) research-based compliance to ensure proactive management and 2) dissemination of new knowledge.

Recommendation Seven - Increase compatible recreation

Several large tracts at SRS may be suitable for low-impact, controlled, outdoor recreational activities—such as hunting, hiking, bird watching, camping, and bicycling—without impacting the site's industrial missions. Also, controlled access would enable other uses to continue unaffected by the increased recreational population.

Recommendation Eight - Increase public education

Public education activities could be greatly expanded without jeopardizing industrial missions. Such expansion, which would meld well with concurrent uses, has received considerable support, and various task groups have been exploring the feasibility of establishing a museum/education/interpretive center on the site. The LUTC endorses this concept.

Recommendation Nine - Establish a land-use decision process

DOE land- and future-use planning is changing. New directives call for an increase in planning, with greater input into the decision-making process. One approach would be to expand the Land-Use Steering Committee—which consists of WSRC senior managers—into a sitewide land-use advisory committee of experts from each major land-use organization. This group would

- advise the DOE-SR site manager about current land uses
- assist in planning other land uses or expanding current uses
- provide expert judgment should land-use conflicts arise

While important for future-use planning, the establishment of use and activity zones was not considered in the LUTC report. Development of planning zones for compatible uses and activities requires a large, time-intensive, concerted effort. The LUTC has resources that can provide active support for development of such a concept. Establishment of a decision hierarchy based on use-compatibility criteria and adherence to the multiple-use concept would strengthen the land-use decision process. The LUTC also strongly endorses establishment of use-compatibility criteria and would provide a lead technical role in such an endeavor.

2.4 Savannah River Operations Office Recommendations

The Department of Energy employees at the Savannah River Site (collectively known as the Savannah River Operations Office, or DOE-SR) have the responsibility for directing and overseeing all Departmental activities at SRS. As part of their ongoing efforts to establish constantly improving, high-quality operations at the site and to support continued viability of surrounding communities in an era of reduced federal budgets and decreasing defense missions, the DOE-SR employees created a strategic plan that sets forth their vision and hopes for the future of the site.

The *SR Strategic Plan*, published in September 1994, promotes a vision of the Savannah River Site as the Department's site of choice for all ongoing and potential DOE missions. To make this vision a reality, the *Strategic Plan* sets several goals as shown below.

- Using the vast scientific and technological assets and expertise at SRS to increase the Nation's global competitiveness and through partnerships with industry, promote economic growth, technology transfer, and creation of high-wage jobs, particularly at the local and regional levels.
- Using the site's core competencies in nuclear energy, national security, and environmental programs to develop new, clean, renewable energy sources and pursue and acquire new missions such as the International Thermonuclear Experimental Reactor, becoming an internationally recognized research center for future energy technologies.
- Sharing assets and expertise through educational outreach programs to help establish the United States as the world leader in science, mathematics, and engineering.
- Playing a key role in meeting DOE's national security requirements and supporting DOE's transition from weapons production to other critical missions, such as stabilization and disposition of nuclear materials, nonproliferation and nontraditional missions.
- Becoming the top-performing DOE site in achieving environmental management excellence by expanding and improving ongoing programs and interactions with regulators and the public to identify, prioritize, and mitigate risks posed by SRS facilities and activities to human health and the environment.

- Maintaining an infrastructure of physical and intellectual assets that is capable of supporting existing and potential new missions in accordance with regulatory and industry standards; preserving, in pristine condition, certain environmental assets with unique ecological biodiversities; and pursuing research initiatives for all these assets on the local, national, and international level.

In addition to the future uses represented in these general goals, there is an overarching future use that both accommodates and supports all of these goals—the site's designation as the country's first National Environmental Research Park.

The Atomic Energy Commission, DOE's predecessor agency, established the NERP concept in 1972 to ensure that the impacts of industrial activities on the natural environment of the sites in the nuclear weapons complex are monitored, analyzed, minimized to the extent practicable, and remediated when necessary. Indeed, research on the interrelationships between the environment and industry has been a hallmark of the site since it was established and constitutes one of the site's most significant legacies.

To preserve this national treasure and ensure the site's long-term commitment to continuing these studies, DOE-SR supports Congressional legislation to formalize the NERP designation in law. The legislative designation would permit a wide variety of activities including industrial research and development in specific areas and environmental research, natural resource management, public education and outreach, and technical training across the site. The Proposed National Environmental Research Park map shows the various areas and possible future uses under the proposed NERP legislation.

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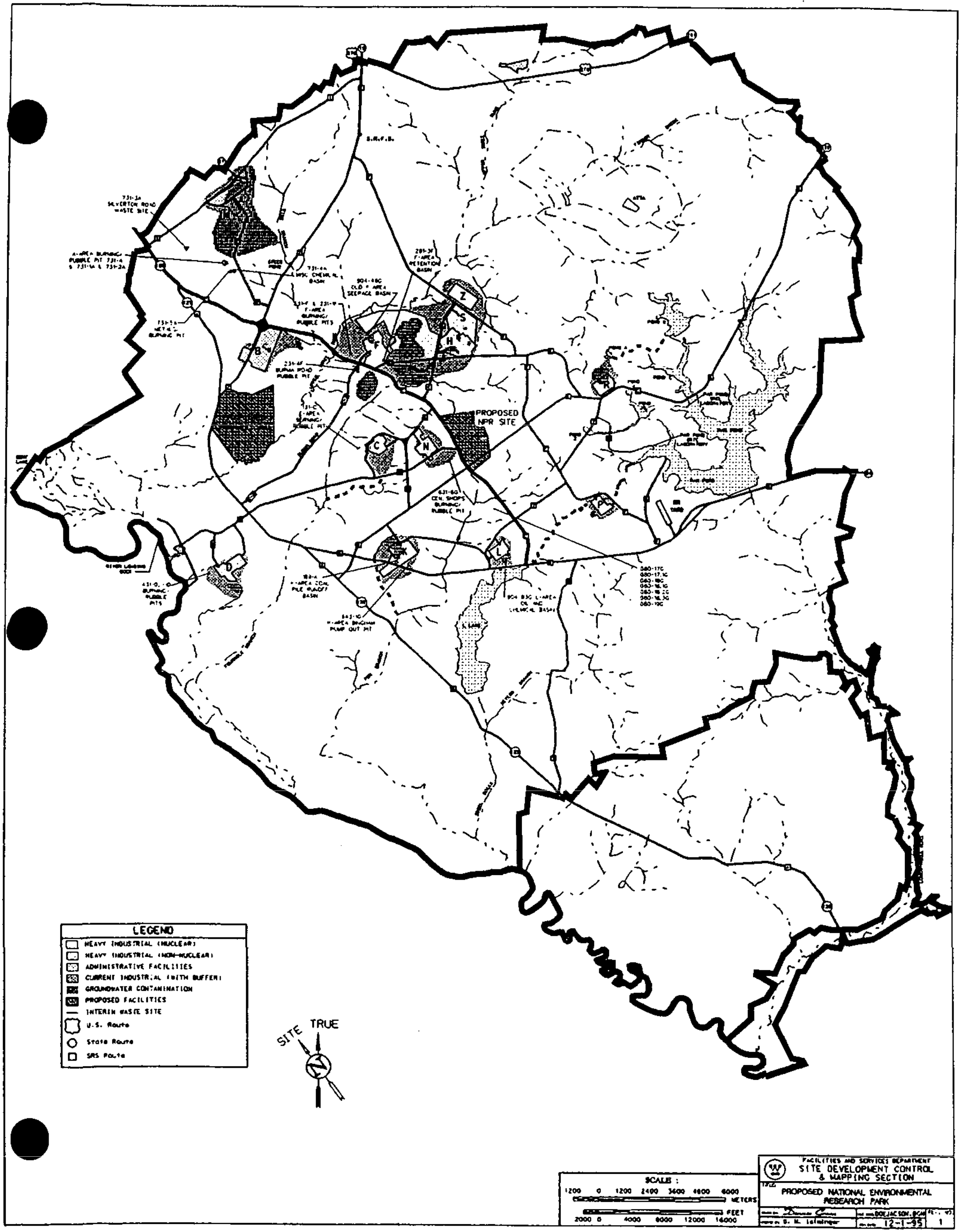
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U.S. Route
State Route
SRS Route
PROPOSED NPR SITE
731-3A SILVERTON ROAD WASTE SITE
281-3F F-AREA RETENTION BASIN
904-49G OLD F AREA SEEPAGE BASIN
631-6G CEN. SHOPS BURNING/RUBBLE PIT
904-83G L-AREA OIL AND CHEMICAL BASIN
643-1G H-AREA BINGHAM PUMP OUT PIT
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2.5 Public Comments

Throughout the Future Use Project process, stakeholders provided comments to the Future Use Project Team by a variety of methods. Most of the comments came from the public meetings; other comments came from the mail or by telephone.

As discussed previously, six public meetings were held in various locations throughout the Future Use Project process. At the Aiken meeting, comments were solicited on the methodology which should be used to reach interested stakeholders. At the North Augusta public meeting, participants reviewed the *DOE-SR Strategic Plan* and the *Land Use Baseline Report*. Many stakeholders who attended this meeting also suggested various types of industrial uses for the land. Solicitations for specific future use recommendations were made at the Barnwell, Beaufort, and Savannah meetings. Since the majority of the participants at the Barnwell meeting were hunters, various types of hunting activities were suggested. At the Beaufort meeting, most stakeholders were former residents of the land and expressed an interest in the return of their property. At the Savannah meeting, only one member of the public attended the meeting whose interest was the present state of the water quality for the Savannah River.

In the *Draft Public Participation Plan* a "strawman" survey was included to be used if the survey method was adopted. As stated earlier, the survey was dropped from the process. However, some people believed that the draft plan included an actual survey to be completed and mailed their comments to the Department by completing this "strawman" survey. Apparently a copy of this survey was sent to many hunting organizations because the vast majority of the surveys sent in were from hunters requesting additional land to be available for various types of hunting. Comments were also received on the two drafts of this report. These comments and responses can be found in Appendix H, *Comments on Draft Future Use Project Report with SRS Responses*.

A brief summary of comments is shown in Section 1.2, *Stakeholder Recommendations for Future Use*. A more comprehensive list of comments is shown in Appendix A, *Responsiveness Summary*.

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Fueling a Competitive Economy, Strategic Plan, U. S. Department of Energy , April, 1994.

Letter, To Distribution, from Donald W. Pearman and Thomas P. Grumbly, Transmittal of Final Draft *Forging the Missing Link: A Resource for Identifying Future Use Options*, January 1994

SRS FY 1995 Draft Site Development Plan, Department of Energy, June 1995.

Savannah River Site Future Use Project Public Participation Plan, Savannah River Site, Revision 1, March 1995.

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Savannah River Operations Office Strategic Plan, U. S. Department of Energy, September 1994.

WSRC Strategic Plan, Building a Secure Future, Westinghouse Savannah River Company, 1994.

Appendix A Summary of Stakeholder Comments for Potential Future Uses

Below is a summary of public comments, from public meetings, written comments, and telephone calls. Many identical comments received have been consolidated. No attempt has been made to quantify the references to any one item. Also, this list is not prioritized in any way. These comments have been placed in land use categories to help the reader find specific comments. The "General Comments Section" was added for comments that did not fit a specific land use category.

Industrial/Commercial

- Commercial industrialization of industrial zones (about 1/3 of the land) shall be actively pursued. Within industrial zones the land is available for multiple use and non-conflicting multiple uses may continue after a site is industrialized.
  - To ensure viability of local region, additional industrialization is needed
  - Opportunity to demonstrate how well industry can be integrated with environmental park
  - Future industrial siting should consider use of adjacent land and incorporate an appropriate buffer
  - Industrial development should be encouraged
  - Industrial sites include current industrial uses and groundwater plumes and 1000-foot buffer
- Using the vast scientific and technological assets and expertise at SRS to increase the Nation's global competitiveness and through partnerships with industry, promote economic growth, technology transfer, and creation of high-wage jobs, particularly at the local and regional levels.
- Using the site's core competencies in nuclear energy, national security, and environmental programs to develop new, clean, renewable energy sources and pursue and acquire new missions such as the International Thermonuclear Experimental Reactor, becoming an internationally recognized research center for future energy technologies.
- Playing a key role in meeting DOE's national security requirements and supporting DOE's transition from weapons production to other critical missions, such as stabilization and disposition of nuclear materials, nonproliferation and nontraditional missions.
- Do not use as a tritium production facility!
- Build future business for the city. They need to clean up the waste before building the city.
- Keep the site as a industrial research park with a mix of nuclear and non-nuclear uses.
- Use the facilities to process fissile material from commercial fuels.
- Continue manufacturing with an environmental mix.
- Consider the medical use of isotopes, maybe from existing high-level waste.
- SRS could be used for energy production, possibly nuclear energy.
- SRS is an ideal area for developing nuclear industrial research.
- Warehousing
- High tech nuclear materials handling/disposal

- Continue industrial uses that support continuing DOE/DOD missions.
- Offices for support personnel
- Do not use it as a tritium production source.
- High tech, service industry
- Light manufacturing; emphasis on nuclear, forest products, and chemicals.
- Laundry, (service without need for much "walk by" traffic)
- "Anti-matter" research and development for an energy source for space exploration
- Low pollution, labor-intensive industry
- Waste management and environmental restoration research and development demonstration projects
- Consolidation of Defense Programs missions; test site for environmental restoration and waste management technologies
- Vehicle manufacture or assembly
- Waste incineration, vitrification
- Research to irrigate deserts, make gas and oil, distill water, treat garbage, recover metals
- Dismantling of weapons, plutonium storage, plutonium reactor
- Heavy/dirty/chemical & manufacturing industries
- Regional recycling center, for goods such as batteries, metal, paper, etc.
- Mixed waste storage, treatment, & advance waste minimization, technology development - also monitored retrievable storage center
- Heavy industry that takes advantage of existing infrastructure
- No industrial use
- Tritium is the best mission for SRS.
- SRS has a base economic development that should diversify with more plants like the John Deere plant in Grovetown.
- Keep the site operating as a regional research and storage facility.
- Keep the site open and active so that it will continue to be an asset, not a burden.
- Make the SRS the "hub" of U.S. nuclear industry.
- Need to improve facilities for water transport via the Savannah River and improve rail connections.
- Because of its isolation and dedicated workforce, we could bring industries to this area that other areas do not want; these industries could be managed effectively at SRS.
- We should commercialize storage and have entities pay the state and SRS for storage.
- There should not be industrial development on the site; research and development cleanup near site; related private development, e.g., plutonium-burning power reactor should be allowed.

Cultural and Archaeological

- Maintain cultural resource compliance
- Use the site for a cemetery.

Residential

- Residential uses of SRS land are to be prohibited.
- Designate no area as residential.
- The land should be developed as another homeless shelter site instead of always wanting to put shelters within the city limits and within residential districts. This area would serve as an opportune place for the shelter. Residential standards for clean-up.
- Clean back to residential standards. Research educational facility concentrating primarily on developing the technology for nuclear cleanup.
- Use for prisons for non-violent criminals.
- Vacation resort area
- The U. S. and Georgia-South Carolina have adequate residential lands - land has not become a premium for residential development.
- Residential development should be located a safe distance from industrial & commercial facilities.
- Residential area should only be on the periphery.
- There should be no residential use; leave off-site to the market.
- The land should be developed as another homeless shelter site.
- It should be a permanent position to prevent any type of life form on this land/site.

Agricultural

- Wood Farming
- Do not use the site for farming or cattle grazing

Recreational

- Increased recreational opportunities shall be actively promoted (with appropriate controls and/or restrictions).
  - Current recreational activities can and should be expanded
  - Other recreational activities should be considered with appropriate restrictions
- Use as a free recreational area for citizens of Savannah and South Carolina.
- Increase compatible recreation
- More diverse public hunting programs
- Walking trails
- Areas should be open for controlled public use.
- Fishing
- Boating
- Camping
- Hiking
- Bird watching
- Nature trails

- Horseback riding
- Savannah River waterfront recreation
- Canoeing
- Photography
- Motor Biking
- 4 wheeling
- Use of Par Pond and L Lake
- River accessed beaches
- Photography
- Do not use the site for social hunting.

Resource Management Areas

- Research and technology demonstration activities shall be actively pursued.
  - SRS was first NERP, as such it is a major center for ecological and radioecological research
  - Areas of contamination can provide opportunities for field testing of new cleanup technologies
  - Opportunities for public education on industrial/ecological interactions should be expanded
  - Land use controls and security systems are important to researchers
- SRS should continue a strong technology transfer program.
- Natural resource management activities in non-nuclear and non-industrial zones shall actively pursue biodiversity.
  - Biological diversity shall be encouraged on SRS lands with special emphasis on non-industrial areas.
- Since the land has a large percentile of forces and farm land, it should become a wildlife and environmental conservatory (Park).
- Use the site as a national environmental research park.
- Should be preserved as a safe site; environmental park.
- Maintain/increase natural resource management.
- Increase environmental/geological research.
- The site should continue to be one of the world's premier natural resource management areas co-located with integrated manufacturing to prove not only that these are not excludable functions, but also demonstrating that these two dissimilar activities can coexist with appropriate planning.
- Site should not hold environmental activities hostage to economic development hopes or plans.
- DOE should ensure that the conclusions of environmental research and findings from natural resource management are published in the casual press (newspapers, etc.) so the local general public can see what a jewel we have at SRS.
- No net wetland loss, continue habitat set-asides.
- Keep the site for ecological and environmental research and education.

- Retained open park land.
- National Wildlife Research Area
- Returned to long leaf pine ecosystem.
- Environmental conservation and research
- With the endangered species at SRS and set-asides for red-cockaded woodpeckers, we should develop a community education effort and re-introduce other endangered species back to SRS land.
- I see deer, turkeys, and other wildlife in my back yard; (her backyard faces SRS property), I would like to continue to see these wildlife and want my children and grandchildren to see them.
- More natural forest management; I am disappointed with the current forest management.
- The Ecology Lab does a tremendous amount of research and educational activities every year—continue that.

General

- SRS boundaries shall remain unchanged and the land shall remain under the ownership of the federal government; national security shall not be compromised.
  - Unforeseen national needs may occur
  - Fair market value of the land is less than estimated cost of remediation
- Multiple uses (excluding residential) shall be considered for individual SRS zones. Land use planning shall be directed toward subdivision of the site into nuclear (defense and commercial), non-nuclear, and environmentally protected sectors. Industrial development may only be located in defined industrial zones.
  - Currently many land areas have several non-conflicting uses
  - Small areas can be dedicated to specific use
  - Examples of concurrent multiple uses include environmental remediation research, ecological research, recreational, ecological preserves, and education and research areas
- Future use planning shall consider the full range of worker, public and environmental risks, benefits and costs.
  - Risks, costs, and resulting benefits must be studied before decisions are made
  - Risks inherent in remediation must be considered (Example: transportation)
  - Public wants to see appreciable benefits and risk reduction for costs of remediation
- Should the federal government decide to sell any of the SRS land, then former landowners (as of 1950-52) and/or their descendants shall have first option to buy back their formerly owned land for uses consistent with land use zones and appropriate standards.
- Sharing assets and expertise through educational outreach programs to help establish the United States as the world leader in science, mathematics, and engineering.
- Becoming the top-performing DOE site in achieving environmental management excellence by expanding and improving ongoing programs and interactions with regulators and the public to identify, prioritize, and mitigate risks posed by SRS facilities and activities to human health and the environment.

- Maintaining an infrastructure of physical and intellectual assets that is capable of supporting existing and potential new missions in accordance with regulatory and industry standards; preserving, in pristine condition, certain environmental assets with unique ecological biodiversities; and pursuing research initiatives for all these assets on the local, national, and international level.
- Make the Savannah River Site become as safe as humanly possible. If not, don't use this area for social hunting, etc. This area is not SAFE for human life as it is now.
- It should be cleaned up to the same standards to which government subjects businesses.
- The use of the land should hinge on the degree the responsible agencies can get it clean. A land "half-cleaned" so to say could leave the "watchdog agency" open to a law suit, the originators of the problem will find an escape route. First priority is cleaning -- the land.
- It should be left alone and preserved. Yes, they should cleanup to a safe standard.
- Remediation then turn to research reservation.
- There should be mixture of uses: 1) light industrial 2) reserved SRS/water contamination/remediation area 3) residential site cleaned to residential environmental standards 4) recreational sites cleaned up per applicable standards.
- DuPont and Westinghouse should clean up the Savannah River Site and should not be a cost left for taxpayers to absorb.
- For the next 20-30 years, the site should not be used for anything but cleanup. After cleanup, the property needs to be used for park, recreation purposes or non-polluting, non-radioactive business purposes.
- How do you clean the site to the levels at which they received it and what do you do with waste, where do you take it? Clean-up to residential standards.
- Environmentally controlled to safe guard for the future of our kids. Discontinue all dumping.
- It is rather difficult to determine this future usage of the land. However, it should be a permanent position to prevent any type of life form on the land/site.
- 1) Area for future testing of chemicals keep isolated. 2) grave site space is needed 3) clean up should be a cautions procedure in eradicating the area. Factors are of natural causes: weather, wind, rain, dry spells.
- Clean-up and leave it until a later date then decide to do whatever it is used as necessary.
- Continue federal ownership, with industrial uses as primary.
- Consider remediation risks and costs.
- Increase public education.
- Establish a land-use decision process.
- Industrial cleanup standards should be applied to industrial areas.
- Studies of human and ecological health must continue.
- Significant levels of contamination are located at specific area on this site; breaking apart the site, or opening it up to unrestricted use, could lead to the premature movement of radionuclides; the longer the site remains intact, possibly more than one century, the safer it will be for unrestricted use.

- SRS is a national asset ; unrestricted use should not be permitted until after its national security mission has been completed.
- Keep separate the issues of national security and environmental remediation; national security should not be a reason to permit environmental contamination, but neither should ER regulations be allowed to affect national security interests.
- Let's open our site for more observance and participation of the beauty of God's earth, but let's not let down our security; we must all take great efforts to safeguard and keep intact the environment and God's bountiful nature as it is.
- Shut SRS down and clean it up.
- Please return all wastes to where it was generated or where it came from.
- Do not use undeveloped land for new development -- use existing industrial sites and leave buffer zone as pristine.
- Offer the land back to the counties.
- Keep future land uses flexible.
- Maintain the site as a unit for potential future federal government purposes.
- Maintain a buffer zone.
- Keep the land for multiple uses.
- Maintain nuclear weapons expertise and safe handling of nuclear materials plus selected commercialization.
- Maintain 300 square miles, nuclear waste handling (saltstone, DWPF), multi-purpose reactor, tritium process, some industry in leased lands - show that industry & environment can live together.
- Isolate permanently high risk areas.
- Cleanup of site and turn over as much as possible to private owners and make use of remainder for public use.
- The level of remediation should be proportional to the use that the given part of the site will play; cost, of course, makes a significant difference; I do disagree with current remediation plans; that is, remediation to an unrestricted use basis (e.g., residential use); site remediation should use the following prioritization scheme; this scheme assumes that the government will maintain the site for the next 25 years and for the 21st century:
    - locations presenting imminent risk to the workers and public should be remediated to a level sufficient for safe controlled use as is proposed
    - locations presenting significant long term risk to the public, under from the controlled use, should be remediated as a second priority
    - third priority should be given to locations that provide risk to the site workers or others using the site; this risk should be evaluated and mitigated, where possible, by specific controls, to levels of remediation to minimize land use concerns
    - fourth priority should be given to remediating the outer zone of the site if required to minimal controls
    - lastly, if money is plentiful, remediate the outer zone of the site to an unrestricted level
- Improve facilities for water transport via Savannah River, improve rail connections.
- Return the land for former residents.

- As a former resident of Ellenton with roots in Dunbarton, I do not wish to take the land back; I would like to visit the areas where my family lived for many generations; I do not feel SRS is a place where I would want to go back to retake the land.
- I am against giving the land to counties; the cities and counties depend on DOE's money in lieu of taxes; this loss of revenue for our local governments would be devastating; privatization would help these local governments.
- No one should get hurt from the contamination at SRS.
- One criteria for decision makers should be risk; to avoid risk exposure, the site should be kept intact until all cleanup is completed; there should be a priority system developed where there would be priorities for the next 5-10 years, 10-25 years, and 25-100 years.
- Recognize that most hazardous areas area a small percentage of the entire site; there is a tremendous amount of land that is uncontaminated.
- We want to see recommendations, not just a report.
- We should look at future use in the long term, not just the present administration; it is clear that this administration wants to dispose of plutonium; this may not be true in future administrations.
- There are but two ways to get public involvement: the ballot box or elected officials; don't call these public meetings "public" input; they are only for special interest groups, as is the CAB.
- Cost is a factor in remediation decisions.
- Cost of remediation does (and should) make a difference; unrestricted access to the entire site would be a ridiculous goal, and "complete" decontamination should not be a requirement for access to any particular area; suggested guidelines include: for controlled areas, ALARA with emphasis on "reasonably"; for uncontrolled areas, 50% above background; for water table, etc., normal unrestricted assumption giving dosages equivalent to 10% of background.
- SRS is (a) an important part of our nation's defense establishment, (b) a major contributor to scientific and technical progress, and (c) a good neighbor in the area.
- There should be a fusion reactor on the central east side of the site for power production and nuclear waste production; there should be heavy industry on the lower east side, a large technology park near New Ellenton, light industry and residential area from Augusta to Aiken on highway, and improved residential area from Williston to Barnwell with a major technology center associated with the University of South Carolina or Clemson; Charleston and Savannah should grow toward the site in support of industry and education complex; this vision needs an area planning or zoning committee or combined chamber of commerce for effective implementation.
- Maintain federal government ownership with management of SRS forests.
- Cleanup the site to the degree necessary to preclude groundwater contamination problems offsite; cost must be a factor.
- Site should be cleaned up to the highest possible standard that technology will accommodate; the development of newer, more efficient, and more scientifically sound technology is encouraged.
- Initiate biological research that use microorganisms to breakdown nuclear radioactive waste that in the process reduces the level of radioactivity.
- Incorporate pollution prevention into all cleanup activities to stop further nuclear contamination.

Appendix B Citizens Advisory Board Vision Document

Appendix B is the Vision document which supports the Savannah River Site Citizens Advisory Board recommendation on future use for the site. The recommendation was passed unanimously at the September 1995 Board meeting and this Vision document, also passed unanimously, was approved at the January 1996 Board meeting.

January 23, 1996

VISION

FUTURE LAND USE - SAVANNAH RIVER SITE

This Vision *document has been a working paper of the Risk Management and Future Use Subcommittee of the Savannah River Site Citizens Advisory Board throughout the discussions on future use in 1995. It formed the basis for the Citizens Advisory Board Recommendation Number 8 which was approved by the Citizens Advisory Board on September 26, 1995. Minor changes have been made in this document to make it consistent with modifications made during Citizens Advisory Board discussion on this recommendation prior to its approval. This version of the* Vision *document (dated January 23, 1996) is the final version and supersedes all previous drafts. This version of the* Vision *was approved by the Citizens Advisory Board on January 23, 1996.*

VISION

The Savannah River Site Citizens Advisory Board Risk Management and Future Use Subcommittee have the following vision for the site:

The Savannah River Site will remain intact, under federal ownership and will become a 21st century role model of the mutually supportive coexistence of advanced industrial and commercial developments, futuristic nuclear enterprises, and an environmental research park. The public will become more knowledgeable on nuclear, industrial, and environmental issues as a result of educational and recreational opportunities at the Savannah River Site which are integrated with the continuing wildlife and natural resources management programs. Privatization of some of the Savannah River Site government-owned facilities will be successfully accomplished through leasing facilities. All stakeholders will work cooperatively to further improve the site. The Savannah River Site will become a vibrant part of the economic health of the Central Savannah River Area.

TRANSFORMATION FROM 1995 TO 2025

The transformation will take place by identification and active pursuit of new governmental missions and private industrial and commercial ventures for the Savannah River Site. Below are two lists of suggestions of possible industrial uses of the site to be considered in future plans for the site, one for possible nuclear uses and one for non-nuclear uses. These are merely lists of possible missions gathered from several sources; the Citizens Advisory Board may not have endorsed any particular mission.

Possible Nuclear Missions (Defense And Commercial)

- Construction and operation of a tritium production and/or processing facility (or facilities) (for example, multi-purpose reactor or accelerator)
- Construction and operation of a prototype fusion power reactor (International Thermonuclear Experimental Reactor)
- Development and operation of a medical radioisotope production facility
- Purification and/or fabrication of plutonium-238 for thermo-electric generators
- Development of a nuclear power park (for example, multiple reactors producing power for commercial purposes)
- Stabilization, dilution, temporary storage, and preparation for disposal of fissile materials
- Demonstration of advanced nuclear power systems
- Demonstration of mixed waste destruction, stabilization, and disposal
- Development of a contaminated metal cleaning and recycle facility
- Development and demonstration of commercial uses for depleted uranium
- Others as identified

Possible Non-Nuclear Missions

- Construction of electro-mechanical facilities (robots, electric cars, decontamination equipment, et cetera)
- Development of hydrogen economy facilities (generation, pumping, separation, storage, hydrogen fueled vehicles, et cetera)
- Development of aluminum and aluminum-alloy parts manufacturing
- Development of additional methods for destruction, stabilization, and disposal of hazardous and sanitary wastes
- Development of fiber manufacture for textiles
- Performance of chemical analyses of environmental samples
- Development and field demonstration of alternative energy production methods (other than coal, oil, gas, hydroelectric or reactor-nuclear) to gain more independence from foreign oil
- Others as identified

In addition to the possible future industrial missions listed above, there are a variety of other missions that can build upon current activities. These possibilities include:

- Development of recreation facilities (hiking, biking, and horseback riding trails; picnic shelters; sanitary and drinking water facilities; boating facilities at Par Pond, et cetera)
- Construction and operation of a visitor and education center, possibly making use of a decommissioned nuclear production reactor
- Enhanced biodiversity and ecological research
- Enhanced controlled hunting (turkey, dove, quail, et cetera); sports fishing opportunities might be developed subject to appropriate restrictions to protect the public

BACKGROUND

This *Vision* reflects the goals for Savannah River Site land uses to satisfy the needs of the nation and the surrounding communities as established by the Citizens Advisory Board. Key participants in development and support of the future of Savannah River Site lands and facilities are the local communities, concerned state agencies, the Savannah River Operations Office of the Department of Energy, the Savannah River Site Management and Operating Contractor, the Savannah River Ecology Laboratory, the U. S. Forest Service, and other internal stakeholders. The Savannah River Site internal stakeholders have prepared a draft report which is consistent with the direction of this *Vision* document. In addition, much input was received from various external stakeholders. The majority of external stakeholder input from the Savannah River Site future use meetings conducted by Savannah River Operations Office of the Department of Energy in late 1994 and 1995 have been included in this document. (See the *Draft Savannah River Site Future Use Project Report*, a Department of Energy report issued in October.) Essential to the implementation of this *Vision* is effective land use planning for the location, integration, and utilization of new facilities with the infrastructure, existing facilities, environmental attributes, and cleanup goals in a cost-effective manner.

Savannah River Site is the United States leader in tritium technology, handling, processing, storing, and recycling and the national leader in high-level waste processing and encapsulation in glass. The site maintains a skilled and highly trained staff with expertise to handle major new missions for the nation. The site has many existing facilities (for example, metal fabrication, radionuclide and hazardous chemical analysis laboratories, heat transfer laboratories, metallurgical facilities, et cetera) that could be reconfigured for commercial enterprises. With its large infrastructure of roads, railroads, steam, sewer, cooling water, drinking water, phone system, et cetera, the site could support a new expanded industrial base.

The current waste management, tritium recycling, decommissioning, decontamination, and environmental remediation missions shall continue as well as the wildlife and natural resources management and environmental research programs. With diverse activities and fewer classified activities at Savannah River Site in the future, security arrangements may need to be reconfigured.

The 310-square miles of Savannah River Site should be zoned for land use planning and control, and such zoning should provide the basis for environmental remediation goals associated with the Federal Facility Agreement. Land use categories are defined by the Comprehensive Environmental Restoration, Compensation and Liability Act or Superfund. (See Appendix 1.) For the Savannah River Site land use planning, the following categories are appropriate:

Citizens Advisory Board Land Uses	Citizens Advisory Board Definition	Comprehensive Environmental Restoration, Compensation and Liability Act Cleanup Standards
Industrial - Nuclear Industrial - Non-Nuclear	Areas of current and possible industrial development	Industrial
Forest and Wildlife Management Recreational Ecological Preserves Education and research	Environmental Protection: Areas to be left in natural state (with no industrial development), but can be used for multiple, concurrent uses.	Recreational with restrictions as described in sub-part 8 of Citizens Advisory Board Recommendation 8.

It is recognized that the industrial area, as shown on the map as part of the Citizens Advisory Board Recommendation Number 8, includes Carolina bays, threatened/endangered species, plant habitats, archaeological sites, et cetera As part of siting a new activity within the industrial zone, the required environmental reviews should consider and protect these areas. [Environmental reviews include National Environmental Policy Act, Clean Water Act, Clean Air Act, Endangered Species Act, wetlands protection, Resource Conservation and Recovery Act, et cetera.]

RECOMMENDATION

To achieve the vision by 2025, the Savannah River Site Citizens Advisory Board makes the following nine-part recommendation for land use and cleanup goals. This recommendation was unanimously approved as Citizens Advisory Board Recommendation Number 8 on September 26, 1995.

(1) *Savannah River Site boundaries shall remain unchanged and the land shall remain under the ownership of the federal government; national security shall not be compromised. Private use of the land will be implemented by lease agreement.*

- Unforeseen national needs may occur
- Fair market value of the land is less than estimated cost of remediation

(2) *Multiple uses (excluding residential) shall be considered for individual Savannah River Site zones. Land use planning shall be directed toward subdivision of the site into nuclear (defense and commercial), non nuclear, and environmentally protected sectors. Industrial development may only be located in industrial zones.*

- Currently many land areas have several non-conflicting uses
- Small areas can be dedicated to specific use
- Examples of concurrent multiple uses include remediation research, ecological research, recreational, ecological preserves, and education and research areas

(3) *Residential uses of Savannah River Site are to be prohibited.*

- Liability concerns and public perceptions of risk would make it difficult to market Savannah River Site land
- Residential development is not consistent with meeting the goals of unforeseen national needs

(4) *Future use planning shall consider the full range of worker, public, and environmental risks, benefits, and costs.*

- Risks, costs, and resulting benefits must be studied before decisions are made
- Risks inherent in remediation must be considered (Example: transportation)
- Public wants to see appreciable benefits and risk reduction for costs of remediation
- Studies of human and ecological health must continue

(5) *Commercial industrialization of industrial areas (about 1/3 of the land) shall be actively pursued. Within industrial zones the land is available for multiple use and non-conflicting multiple uses may continue after a site is industrialized.*

- To ensure viability of local region, additional industrialization is needed
- Opportunity to demonstrate how well industry can be integrated with environmental park
- Future industrial siting should consider use of adjacent land and incorporate appropriate buffer
- Industrial development should be encouraged
- Industrial sites include industrial uses and groundwater plumes and 1000-foot buffer
- Industrial cleanup standards should be applied to industrial areas
- Areas of contamination can provide opportunities for field testing of new cleanup technologies
- Opportunities for public education on industrial/ecological interactions should be expanded
- Land use controls and security systems are important to researchers
- Savannah River Site should continue a strong technology transfer program

(6) *Research and technology demonstration activities shall be actively pursued.*

- Savannah River Site was first National Environmental Research Park, as such it is a major center for ecological and radioecological research
- Areas of contamination can provide opportunities for field testing of new cleanup technologies
- Opportunities for public education on industrial/ecological interactions should be expanded
- Land use controls and security systems are important to researchers
- Savannah River Site should continue a strong technology transfer program

(7) *Natural resource management activities in non-nuclear and non-industrial zones shall actively pursue biodiversity*

- Biological diversity shall be encouraged on Savannah River Site lands with special emphasis on non-industrial areas.

(8) *Increased recreational opportunities shall be actively promoted (with appropriate controls and/or restrictions).*

- Current recreational activities can and should be expanded
- Other recreational activities should be considered with appropriate restrictions

(9) *Should the federal government decide to sell any of the Savannah River Site land, then former landowners (as of 1950-52) and/or their descendants shall have first option to buy back their formerly owned land for uses consistent with land use zones and appropriate standards.*

BACKUP INFORMATION

The following information is provided to explain each part of the recommendation in more detail. Each subpart of the recommendation is in the boxed areas shown below with an explanation following the box.

(1) *Savannah River Site boundaries shall remain unchanged and the land shall remain under the ownership of the federal government; national security shall not be compromised. Private use of the land will be implemented by lease agreement.*

- Unforeseen national needs may occur
- Fair market value of the land is less than estimated cost of remediation

The federal government must remain the owner of the current Savannah River Site land area for future, unforeseen national needs that might require such a land area; it would be difficult to obtain such a large land area today. The federal government also is liable for the cleanup required by environmental laws consistent with land use described in this document and the Citizens Advisory Board Recommendation Number 8.

(2) *Multiple uses (excluding residential) shall be considered for individual Savannah River Site zones. Land use planning shall be directed toward subdivision of the site into nuclear (defense and commercial), non nuclear, and environmentally protected sectors. Industrial development may only be located in industrial zones.*

- Currently many land areas have several non-conflicting uses
- Small areas can be dedicated to specific use
- Examples of concurrent multiple uses include remediation research, ecological research, recreational, ecological preserves, and education and research areas

Savannah River Site must be managed in such a way that the majority of the site land is available for an urgent national need if required in the future. The 310-square mile Savannah River Site is a multiple-use site now (1995) with many land areas having several different, non-conflicting uses with small areas dedicated to a specific use. This multiple use should continue. In the Recommendation Number 8 map, the primary use is shown for industrial areas, but other non-conflicting uses can be made in these industrial areas. For non-industrial areas, it is not always possible to distinguish between forest and wildlife management, recreational, ecological preserves, education, and research areas, as many of these uses occur simultaneously on the same area of land. Examples of concurrent, multiple uses include environmental remediation research, ecological research, and habitats for endangered species. Additional data exists in the *Savannah River Site Land Use Baseline Report*, June 1995. The Recommendation Number 8 map and this document should be used as a basis for site planning.

(3) *Residential uses of Savannah River Site are to be prohibited.*

- Liability concerns and public perceptions of risk would make it difficult to market Savannah River Site land
- Residential development is not consistent with meeting the goals of unforeseen national needs

(4) *Future use planning shall consider the full range of worker, public, and environmental risks, benefits, and costs.*

- Risks, costs, and resulting benefits must be studied before decisions are made
- Risks inherent in remediation must be considered (Example: transportation)
- Public wants to see appreciable benefits and risk reduction for costs of remediation
- Studies of human and ecological health must continue

(5) *Commercial industrialization of industrial areas (about 1/3 of the land) shall be actively pursued. Within industrial zones the land is available for multiple use and non-conflicting multiple uses may continue after a site is industrialized.*

- To ensure viability of local region, additional industrialization is needed
- Opportunity to demonstrate how well industry can be integrated with environmental park
- Future industrial siting should consider use of adjacent land and incorporate appropriate buffer
- Industrial development should be encouraged
- Industrial sites include industrial uses and groundwater plumes and 1000-foot buffer
- Industrial cleanup standards should be applied to industrial areas
- Areas of contamination can provide opportunities for field testing of new cleanup technologies
- Opportunities for public education on industrial/ecological interactions should be expanded
- Land use controls and security systems are important to researchers
- Savannah River Site should continue a strong technology transfer program

Industrial uses are further subdivided into current (1995) and possible industrial zones on the Recommendation Number 8 map. The site should continue to develop a strong technology transfer program that is the basis for new private industrial development. These industrial areas also include groundwater contamination plumes with a 1000-foot buffer that are an integral part of the Citizens Advisory Board Recommendation 2 of January 24, 1995. Monitoring the groundwater plume should continue and control activities should protect the public health. In industrial areas, protection can be obtained by providing alternative sources of drinking water. Industrial cleanup standards should generally be applied to industrial areas.

The industrial zones are divided into nuclear and non-nuclear zones. Either government or private enterprise (under long-term leases) could establish new missions in these zones but each specific proposed site would undergo the specific site-use approval process and appropriate environmental reviews (National Environmental Policy Act, Clean Water Act, Clean Air Act, Endangered Species Act, wetlands protection, Resource Conservation and Recovery Act, et cetera) before final approval.

In general, the nuclear zone is near the center of the site and includes the existing nuclear facilities. The non-nuclear industrial zone is near A, M, B, D and TNX areas and along Highway 125 between Savannah River Site Roads 1 and 6. Within these zones, other activities could take place such as timber operations, wildlife management, environmental research, and field-related educational activities until a specific area is needed for industrial development. If any land is removed from an industrial zone through rezoning, then cleanup levels for contaminated areas must be re-evaluated.

The remaining portions of the land are designated for multiple use (that is, forest and wildlife management, recreational, ecological preserves, and education and research). These areas should be cleaned up to recreational standards with appropriate controls established on the use of the land.

As an example of an area that needs appropriate controls, some Savannah River Site lands have residual contamination from past releases from Savannah River Site facilities. In particular, there is cesium-137 contamination in many of the Savannah River Site waterways from releases in the 1960s. These are detectable, are above global background levels, are well mapped, and are being allowed to radioactively decay in place. (Cesium-137 has a 30-year half life.)

Besides cesium-137 there are other radionuclides detectable above global background levels in the Savannah River Site (that is, tritium, uranium, iodine-129, plutonium-238, plutonium-239, carbon-14, et cetera); but the same commitments on appropriate controls should apply.

Existing areas of contamination at Savannah River Site provide an opportunity for field testing of new cleanup technologies. This type of activity should be increased to develop more cost-effective technologies for cleanup throughout the United States. Savannah River Site, with its land area and technical staff, is an ideal location to perform these field tests.

There is currently a system in place to approve and coordinate specified land uses at Savannah River Site; this should continue as a method of appropriate controls of land use.

(6) *Research and technology demonstration activities shall be actively pursued.*

- Savannah River Site was first National Environmental Research Park, as such it is a major center for ecological and radioecological research
- Areas of contamination can provide opportunities for field testing of new cleanup technologies
- Opportunities for public education on industrial/ecological interactions should be expanded
- Land use controls and security systems are important to researchers
- Savannah River Site should continue a strong technology transfer program

The primary land use in the Education and Research category is for student and public education, research on the structure and function of ecosystems, and the interaction of industrial facilities with the environment. Basically this can be done on any of the 310-square miles of the Savannah River Site on a non-interfering basis through specific site-use requests approved by Department of Energy. The ability to have a protected environmental research field site, because of land use control and security systems at Savannah River Site, is a very valuable attribute for researchers. Education and research facilities should be maintained and operated throughout the site by a variety of contractors.

Savannah River Site was the first National Environmental Research Park designated by the Department; is a major center of ecological research; and is the major field site for radioecological research in the United States. It is considered a national asset because it is uniquely suited for the demonstration of new environmental restoration technologies. These research and technology demonstrations should be actively pursued.

(7) *Natural resource management activities in non-nuclear and non-industrial zones shall actively pursue biodiversity*

- Biological diversity shall be encouraged on Savannah River Site lands with special emphasis on non-industrial areas.

Presently Savannah River Site has about 90% of its land used for timber production, natural resource and wildlife management, and environmental research. This research includes studying thermal effects on aquatic organisms, studying the effects of coal power plants on the environment, studying the transfer of radionuclides through various environmental pathways, et cetera; these activities should continue and be increased. Opportunities for public education on these industrial/ environmental interactions should be expanded.

Ecological preserves have been established and should continue to be protected to follow the evolution of natural ecosystems over time. Biodiversity should be encouraged with special emphasis on non-industrial areas. Limited use should be made of this area for education and research, as long as any man-made disturbance to the area is at an absolute minimum. If any waste sites exist in these areas and if any cleanup is required, it should be done with an absolute minimum impact on the environment. Department of Energy, with stakeholder input, shall identify the areas of major set-asides as ecological preserves.

(8) *Increased recreational opportunities shall be actively promoted (with appropriate controls and/or restrictions).*

- Current recreational activities can and should be expanded
- Other recreational activities should be considered with appropriate restrictions

The Savannah River Site lands can and should provide major opportunities for public recreation. Some recreational activities occur now (that is, deer and hog hunting), but this can and should be actively promoted so that local residents can benefit from such opportunities. Examples include turkey hunting; hiking, biking and horseback riding trails; fishing; boating, et cetera.

There should be appropriate restrictions on some recreational activities such as water skiing, swimming, et cetera.

(9) *Should the federal government decide to sell any of the Savannah River Site land, then former landowners (as of 1950-52) and/or their descendants shall have first option to buy back their formerly owned land for uses consistent with land use zones and appropriate standards.*

Due to the concern of former residents of the land where Savannah River Site is now located, the Citizens Advisory Board believes that this group of people should have the right of first refusal to buy their formerly owned land, if it should ever become available. Evaluation of the particular parcels of land and cleanup to Comprehensive Environmental Restoration, Compensation and Liability Act residential standards must be done by the federal government prior to the release of that land. However, the Citizens Advisory Board does not believe this land should be available for sale.

CONCLUSION

Thus, in the 21st century, the Savannah River Site will continue and strengthen its role as the premier national environmental research park with the addition of new major missions: meeting the government needs, developing industrial uses with private industry, stabilizing closed nuclear facilities, cleanup of environmental contamination, enhanced educational opportunities and ecological research and developing recreational opportunities. Careful planning, adequate resources, and determined execution will result in harmonization of these missions.

APPENDIX 1 TO THE VISION DOCUMENT

Land Use Categories, As Defined Under Comprehensive Environmental Restoration, Compensation and Liability Act Guidance Documents

Under current environmental guidance document, when deciding the appropriate technology for cleanup and the resulting costs, a risk assessment is done to determine the risks once a future land use is determined. The guidance includes the following definitions and guidance for various risks:

Residential — Residential exposure scenarios and assumptions should be used whenever there are or may be occupied residences on or adjacent to the site. Under this land use, residents are expected to be in frequent, repeated contact with contaminated media. The contamination may be on the site itself or may have migrated from it. The assumptions in this case account for daily exposure over the long term and generally result in the highest potential exposures and risk.

Commercial/Industrial — Under this type of land use, workers are exposed to contaminants within a commercial or industrial site. These scenarios apply to those individuals who work on or near the site. Under this land use, workers are expected to be routinely exposed to contaminated media. Exposure may be lower than that under the residential scenarios, because it is generally assumed that exposure is limited to 8 hours a day for 250 days per year.

Agricultural — These scenarios address exposures to people who live on the property (that is, farm family) and agricultural workers. Assumptions made for worker exposures under the industrial/commercial land use may not be applicable to agricultural workers due to differences in workday length, seasonal changes in work habits, and whether migrant workers are employed on the affected area. Finally, the farm families live in the area.

Recreational — This land use addressed exposures to people who spend a limited amount of time at or near the site while playing, fishing, hunting, hiking, or engaging in other outdoor activities. This includes what is often described as the "trespasser" or "site visitor" scenario. Because not all sites provide the same opportunities, recreational scenarios must be developed on a site-specific basis. Frequently, the community surrounding the site can be an excellent source of information regarding the current and potential recreational use of the site. The RPM/risk assessor is encouraged to consult with local groups to collect this type of information.

In the case of trespassers, current exposures are likely to be higher at inactive sites that at active sites because there is generally little supervision at abandoned facilities. At most active sites, security patrols and normal maintenance of barriers such as fences tend to limit (if not entirely prevent) trespassing. When modeling potential future exposures in the baseline risk assessment, however, fences should not be considered a deterrent to future site access.

Recreational exposure should account for hunting and fishing seasons where appropriate, but should not disregard local reports of species taken illegally. Other activities should also be scaled according to the amount of time they actually occur, for children and teenagers, the length of the school year can provide a helpful limit when evaluating the frequency and duration of certain outdoor exposures.

Department of Energy
Savannah River Operations Office
P.O. Box A
Aiken, South Carolina 29802

DEC 20 1995

Dr. Mildred McClain, Co-Chair
Savannah River Citizens Advisory Board
720 Maupas Avenue
Savannah, GA 31401

Mr. Bob Slay, Co-Chair
Savannah River Citizens Advisory Board
P.O. Box 192
Beech Island, SC 29842

Dear Dr. McClain and Mr. Slay:

SUBJECT: Citizens Advisory Board's (CAB's) Eighth Recommendation - Future Uses of Savannah River Site (SRS) (Your letter, 10-03-95)

Thank you for submitting your eighth recommendation to the Department of Energy (DOE) regarding the future uses of SRS. We agree with the substance of your recommendation. It is very similar to our own internal ideas of designating the SRS as a National Environmental Research Park (NERP) and to the many comments received during the SRS Future Use Project.

Your recommendation has been incorporated into the draft SRS Future Use Project Report, which is currently being revised to reflect your comments provided at the November 28, 1995, Board meeting. While we are in substantial agreement with the CAB's proposal, we take the following minor exceptions:

- Under the NERP proposal, Savannah River Operation Office's (SR's) intent is to limit industrial development to those areas currently being used for industrial purposes. This will not necessarily limit any future development of those areas, but will provide maximum flexibility for use of the land.
- As far as recreational opportunities are concerned, we have recently expanded the hunting opportunities in the Crackerneck portion of the site. While we will continue to review recreational proposals on a case-by-case basis, we believe it is prudent to take a conservative approach for the foreseeable future, rather than "actively promote" increased recreational activities at the site.
- SR also agrees with the intent of the ninth part of your recommendation, but in accordance with current laws and regulations, we have no mechanism to give first refusal to former property owners. In fact, those regulations specify a procedure for disposing of excess property.

These differences will be discussed in more detail in the report. It is our intent to discuss these with you prior to distributing another version of the report. This report, along with your recommendation, will be used for future planning and decision-making activities for this site.

Again, thank you for your timely and important recommendation.

Sincerely,

Mario P. Fiori
Manager

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Appendix C Citizens for Environmental Justice Recommendations

The information provided in Appendix A is shown as it was given to DOE by the group, Citizens for Environmental Justice, as their recommendation for future land use. The Citizens for Environmental Justice came into being to help increase the level of participation of people of color in the work for a safe and clean environment. This group's main focus is in the African-American community, but works with all people who are struggling for environmental justice. This organization educates, organizes, and mobilizes the Black community to actively work in protecting human resources as well as water, air, and land resources.

These responses represent a synthesis of all the comments received. They do not reflect any order of priority.

How should the land be used at the Savannah River Site in the Future?

The overriding theme was that cleanup to industrial standards was the minimum standard to be applied as decisions are made.

- Do not use it for farming or cattle raising. It is unsafe even to wildlife. Use for a cemetery only.
- It should not be used for residential property.
- Store other waste material. Use it as a grave yard for the community after cleanup.
- Make the Savannah River Site become as safe as humanly possible. If not, don't use this area for social hunting, etc. This area is not SAFE for human life as it is now.
- It should be cleaned up to the same standards to which government subjects businesses.
- The use of the land should hinge on the degree the responsible agencies can get it clean. A land "half-cleaned" so to say could leave the "watchdog agency" open to a law suit, the originators of the problem will find an escape route. First priority is cleaning -- the land.
- Do not use as a tritium production facility!
- Clean back to residential standards. Research educational facility concentrating primarily on developing the technology for nuclear cleanup.
- It should be left alone and preserved. Yes, they should cleanup to a safe standard.
- Remediation then turn to research reservation.
- There should be mixture of uses: 1) light industrial 2) reserved SRS/water contamination/remediation area 3) residential site cleaned to residential environmental standards 4) recreational sites cleaned up per applicable standards.
- Use as a free recreational area for citizens of Savannah and South Carolina.

- The land should be developed as another homeless shelter site instead of always wanting to put shelters within the city limits and within residential districts. This area would serve as an opportune place for the shelter. Residential standards for clean-up.
- Build future business for the city. They need to clean up the waste for the up build of the city.
- DuPont and Westinghouse should clean up the Savannah River Site and should not be a cost left for taxpayers to absorb.
- For the next 20-30 years, the site should not be used for anything but cleanup. After cleanup, the property needs to be used for park, recreation purposes or non-polluting, non-radioactive business purposes.
- How do you clean the site to the levels at which they received it and what do you do with waste, where do you take it? Clean-up to residential standards.
- Environmentally controlled to safe guard for the future of our kids. Discontinue all dumping.
- It is rather difficult to determine this future usage of the land. However, it should be a permanent position to prevent any type of life form on the land/site.
- Since the land has a large percentile of forces and farm land, it should become a wildlife and environmental conservatory (Park).
- Use the site as a national environmental research park.
- Clean-up and leave it until a later date then decide to do whatever it is used as necessary.
- Should be preserved as a safe site; environmental park.
- 1) Area for future testing of chemicals keep isolated. 2) grave site space is needed 3) clean up should be a cautions procedure in eradicating the area. Factors are of natural causes: weather, wind, rain, dry spells.

95% of the respondents stated there should be no cuts in the "clean-up" budget by Congress.

Addendum

"Charting a New Course" Community Conference, September 23, 1995

Overall Summary

It was strongly urged and reiterated that the Savannah River Site's land be used for a cemetery only, because of the level of contamination it should and could not be used for any other reasons.

Overall Recommendations

- It was suggested that the land never be used for inhabitation by stakeholders.
- Only trained personnel should be allowed to work and inhabit the land.
- Continued research on the site was also recommended.

Community Perspective

Overall, the community exhibited distrust with the whole idea of any future use of land masses that are so thoroughly contaminated with all major categories of highly radioactive nuclear waste along with tons of contaminated equipment, supplies, and clothing. There was agreement that the site should be cleaned up to the highest possible standard that technology will accommodate. The development of newer, more efficient, and more scientifically sound technology was encourage.

Scientific Recommendations

- Initiate biological research that use microorganisms to breakdown nuclear radioactive waste that in the process reduces the level of radioactivity.
- Incorporate pollution prevention into all clean-up activities to stop further nuclear contamination.

Citizens for Environmental Justice Stakeholder Survey

1. Do you think current zoning laws should be changed to prevent residential areas from being located near industries that pose a potential threat to health?

   _____yes _____no

2. Should industry be responsible for compensating residents?

   _____yes _____no

3. Should there be a citizens oversight board?

   _____yes _____no

4. Should Congress cut the budget for clean-up at the Savannah River Site?

   _____yes _____no

5. How should the land be used at Savannah River Site in the future?

   _____yes _____no

Appendix D SRS Land Use Technical Committee Recommendations

The Land Use Technical Committee is a group of 23 senior technical experts from all major site organizations. The recommendations shown below is quoted from their report of their recommendations verbatim. This group worked for over two years to develop these recommendations, using their site expertise.

Introduction And Overview

The U. S. Department of Energy (DOE) has requested that each of its sites prepare a report depicting stakeholder preferences for future use, given each site's unique characteristics. The purpose of this document is to provide the conceptual design of the future use of the Savannah River Site, as envisioned by the internal stakeholders represented by the site's Land Use Technical Committee (LUTC). The document will serve as a guide for program planning, facility siting, and waste site remediation. Both the opportunities and the limitations of SRS land and existing facilities, as well as regional economic development goals, have been considered in arriving at recommended primary future use and ancillary activities. While many future "uses" are envisioned for the site, a "primary use" has been recommended to meet the requirements of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). Compatible land-use activities also were listed to illustrate that the "multiple land use" concept should continue to be employed at SRS. The LUTC recommends that the primary future use be industrial and that primary supporting activities be consistent with the site's designation as a National Environmental Research Park (NERP).

This report was compiled by the LUTC, which is a comprised of 23 senior technical experts from all major site organizations who supply in-depth technical land-use technical analysis to site management regarding project siting, land-use conflict resolution and planning, and CERCLA and RCRA compliance.

The report's future use recommendations are expected to help DOE determine suitable activities that are compatible with primary use. The LUTC recommends that all site land remain under federal ownership, but notes that some land and facilities could be used by public or private sectors in a lease agreement with the federal government. Because many areas are suitable for multiple uses, the LUTC did not propose specific uses for specific areas; these will be decided via established policy and internal regulations.

Policy Guidance, Plans And DOE Orders

Possible future-use options at SRS will be subject to administrative constraints stemming from federal, state, and local laws, regulations, permits, and agreements, as well as DOE orders, policy, guidelines, directives, and mission plans. Under the National Environmental Policy Act (NEPA), RCRA, CERCLA, and other statutes, DOE must consider the ecological health and ultimate fate of its natural resources in land-use planning—and is liable for damages resulting from CERCLA releases of contaminants.

CERCLA is the driving force for most SRS remediation activities. The U. S. Environmental Protection Agency (EPA) has assumed under CERCLA that land will be become residential unless it is in areas where residential use is unreasonable. Consequently, it is implied that the cleanup standard for contaminated waste sites is residential, which assumes that a family would live on the land and obtain their drinking water from a well at the site, and that their children would plan in and eat the dirt. From a land-use planning perspective, this is unrealistic and unreasonable for site having a continuing DOE-managed mission with stringent safety/security measures. EPA recently issued new guidance on land use, stating that the CERCLA baseline risk assessment "generally needs only to consider the reasonably anticipated land use." This supports the LUTC recommendation that the site's primary future land use remain industrial.

Primary Future Land Use

Industrial

The primary industrial future use for SRS relates to continuing missions related to stabilization and preparation for disposal of high- and low-level wastes, management of surplus nuclear materials, and support of the nation's nuclear weapons stockpile. In addition, related nonnuclear industrial missions would be able to utilize the site's unique infrastructure. The site is one of the few areas in the nation that can support future missions with a combination of extensive industrial production areas, existing infrastructure, and a substantial buffer zone from the public. In addition to nuclear uses, future compatible industrial uses could include commercial industrial development and technology demonstration.

Land-Use Activities Compatible With Industrial Use

The LUTC has carefully considered the following complementary activities that would support the site's primary mission:

- environmental and geological research (including continuation and expansion of NERP program)
- natural resource management
- cultural resource management
- recreation
- public education

LUTC Concept of Future Use of SRS — Multiple and Compatible Uses

LUTC future-use recommendations are based on multiple use, in which many compatible uses and activities can "occupy" or use the same space simultaneously. Multiple-use management focuses on optimizing the functions of the entire ecosystem.

SRS has informally used a classic ring—or "target"—approach to land-use planning, with the center ring being an industrial area and surrounding areas being security and/or safety buffers. This concepts locates within the inner ring all facilities that handle or process radioactive materials. Nuclear materials outside the ring ultimately would be decommissioned or relocated.

LUTC Recommendations For Future Uses Of SRS

Recommendation One - Continue federal ownership, with industrial uses as primary

It is proposed that the site remain under federal control and that industrial uses continue as in the past, with emphasis on stabilization activities of surplus materials and facilities. However, the percentages of land used for particular activities may change (current percentages are 15 percent developed and 83 percent undeveloped). Except for inquiries from former site residents, there appears to be no public demand for SRS land. Although contaminated areas and waste sites do not present an immediate threat to public and environmental health, the contamination is dispersed across much of the site, thus rendering most areas of the site incompatible with public transference. Additionally, regulators have indicated they would oppose any move to release land that had not been cleaned up to residential standards. SRS has demonstrated that many diverse activities can coexist. Eliminating federal ownership would significantly affect these relationships and eliminate some of them altogether. Also, the number, time frame, complexity, and costs of required studies would be major impediments to an SRS real estate turnover.

Recommendation Two - Increase environmental/geological research

SRS leads the DOE complex in many areas: established as the first NERP in 1972; known as a leader in environmental remediation technologies; and seen as a treasure trove of cultural information. The unique research conducted by the Savannah River Forest Station (SRFS) and the reputations of the Savannah River Ecology Laboratory (SREL), and Savannah River Technology Center, and the Savannah River Archaeological Research Program (SRARP) contribute to the viability of potential future uses for SRS. Researchers have indicated that foundation, university, and government funding support would be forthcoming with a more stabilized planning base. The research and technology application also could expand to unexploited areas of study, such as algaculture, aquaculture, and medicine—and could broaden current programs in

- bioremediation
- forest products
- the fate and effects of contaminants in the environment
- archaeology and cultural anthropology

Recommendation Three - Designate no area as residential

A number of reasons preclude "residential" designation for SRS. First is contamination. While the most dangerous contamination is contained and is not a health hazard, remediation cannot be accomplished in some site areas—mostly water bodies—with today's technology. While most site land is free of contamination, future residences could be located near water bodies, which may present a risk, albeit, remote, to full-time residents. For protection, each water body would have to be fenced and patrolled, and such restrictions would create an unacceptable, checkerboard pattern of land use. Also, many research projects, technology demonstrations, meteorological towers, and monitoring devices would have to be relocated or eliminated. Finally, federal liability has not been determined. With controlled access, the government can be reasonably assured that the public and site employees will not be exposed to undue risks. With unrestricted public access, however, government liability would need to be determined. Thus, the government should maintain ownership responsibility and ultimate oversight of SRS.

Recommendation Four - Consider remediation risks and costs

Because of SRS's mix of contamination and the constraints surrounding remediation program budgets, there are limits on how much of the site can reasonably be remediated to regulation-acceptable levels. Therefore, efforts should concentrate on containment and monitoring to protect public health and the environment and on the cleanup of areas that may limit future land-use activities.

Recommendation Five - Maintain/increase natural resource management

Natural resource management activities play a significant role at SRS. Increases in these activities could enhance other future uses. For example, using the present acreage of forested lands and the concept of multiple-use management, additional opportunities can be created for recreation, education, and research. According to the Water Branch of Georgia's Environmental Protection Division, very little assimilative capacity is left in the Savannah River because of waste dumping by industries and municipalities. Consequently, keeping large areas such as SRS along the river in a relatively natural state would preserve the site's environmental integrity and promote offsite river development.

Recommendation Six - Maintain cultural resource compliance

The SRARP's primary purpose is to provide DOE-SR with recommendations about cultural resource management to ensure that DOE remains in compliance with federal laws and regulations. Because proper management of these resources depends on assessment of archaeological site significance, SRARP began a phased approach to compliance in 1973 with a program of reconnaissance, watershed, and project-specific surveys and of excavation. This program, conducted in conjunction with major land users, helps identify and preserve SRS cultural resources. Cultural research provides background data for former landowners and Native American constituencies and assists local planners. Resource management activities should continue to focus on 1) research-based compliance to ensure proactive management and 2) dissemination of new knowledge.

Recommendation Seven - Increase compatible recreation

Several large tracts at SRS may be suitable for low-impact, controlled, outdoor recreational activities—such as hunting, hiking, bird watching, camping, and bicycling—without impacting the site's industrial missions. Also, controlled access would enable other uses to continue unaffected by the increased recreational population.

Recommendation Eight - Increase public education

Public education activities could be greatly expanded without jeopardizing industrial missions. Such expansion, which would meld well with concurrent uses, has received considerable support, and various task groups have been exploring the feasibility of establishing a museum/education/interpretive center on the site. The LUTC endorses this concept.

Recommendation Nine - Establish a land-use decision process

DOE land- and future-use planning is changing. New directives call for an increase in planning, with greater input into the decision-making process. One approach would be to expand the Land-Use Steering Committee—which consists of WSRC senior managers—into a sitewide land-use advisory committee of experts from each major land-use organization. This group would

- advise the DOE-SR site manager about current land uses
- assist in planning other land uses or expanding current uses
- provide expert judgment should land-use conflicts arise

While important for future-use planning, the establishment of use and activity zones was not considered in this report. Development of planning zones for compatible uses and activities requires a large, time-intensive, concerted effort. The LUTC has resources that can provide active support for development of such a concept. Establishment of a decision hierarchy based on use-compatibility criteria and adherence to the multiple-use concept would strengthen the land-use decision process. The LUTC also strongly endorses establishment of use-compatibility criteria and would provide a lead technical role in such an endeavor.

Conclusion

In this report, the LUTC has used its cumulative knowledge to present an appraisal of future land use. While no one can predict the future, the LUTC has provided its best judgment on the utilization of site attributes that will most wisely use the physical and natural resources of SRS. The committee envisions expanded, dynamic site functions that meet the needs of the country and respond to regional concerns. From a land-use perspective, there is considerable capacity for expanding both the primary industrial use and the compatible supporting facilities. The committee believes that a site as unique as SRS can meet the needs of diverse interest groups.

EXECUTIVE SUMMARY

The Department of Energy has charged each site to prepare a future use report that depicts stakeholder preferences for future use, given each site's unique characteristics. The purpose of this document is to provide the conceptual design of the future use of the Savannah River Site including its existing facilities as envisioned by internal stakeholders represented by the Land Use Technical Committee (LUTC). The document is to serve as a guide for program planning, facility siting and remediation of waste sites. Both the opportunities and limitations of the land and existing facilities at the SRS, as well as regional economic development goals, have been considered in arriving at the recommended primary future use and ancillary activities. While there are many future "uses" envisioned for the site, a "primary use" (industrial) has been recommended to meet the requirements of Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). Compatible land use activities were also listed to illustrate that the "multiple land use" concept could be employed at SRS. The LUTC recommends that the primary future use of the site be industrial with primary supporting activities being consistent with the site's designation as a National Environmental Research Park. [DOE Headquarters defines a NERP as a field laboratory set aside for conducting ecological research, studying environmental impacts of energy development and informing the public of environmental and land use options.]

The SRS Land Use Technical Committee has completed an analysis of the issue of future SRS use and has developed recommendations listed below. The background and justification for each recommendation begin on page 8. While it is envisioned that all land on the site will remain under federal control in support of planned or unforeseen future DOE missions, some of the land could be used by the public or private sector via special arrangements with the government.

RECOMMENDATIONS FOR FUTURE USE

Industrial Use

SRS boundaries should not change and the primary future land use should continue to be industrial, with multiple, concurrent supporting land use activities.

Environmental and Geological Research

Consistent with designation of the site as a National Environmental Research Park, research and related technology demonstration activities should be increased.

Residential Use

No area of the site should be designated as potential "residential" areas.

Consideration of Risks and Costs

Future use planning should consider the full range of risks and costs associated with remediation.

Resource Management

Natural resource management activities should be maintained/increased.

Cultural Resources

Cultural resource compliance activities should be maintained at current levels to ensure pro-active management.

Recreation

Recreation activities compatible with other site uses and activities should be increased.

Education

Public education activities should be significantly increased.

Land Use Decision Process

Additional mechanisms should be established to assist the DOE-SR Site Manager in the land use decision process.

SRS' LAND USE TECHNICAL COMMITTEE'S FUTURE USE REPORT

INTRODUCTION AND OVERVIEW

The purpose of this report is to provide technical guidance to site decision makers from "internal stakeholders" regarding the selection of a primary future use of SRS land and facilities. When the primary future use is decided by the Department of Energy (DOE) with input from stakeholders, remediation decisions can be made based on realistic future uses; "Superfund" and RCRA goals can be addressed; and future project siting and economic development goals will be enhanced. This report was compiled by the SRS Land Use Technical Committee (LUTC), which is comprised of 23 senior technical experts from all the major site organizations representing all major program areas. The LUTC was chartered to supply in-depth land use technical analysis to site management with regard to project siting, resolution of land use conflicts and land use planning. - as well as with Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA) compliance. If, for example, a contaminated area will be used for homes in the future, its clean-up goals may be very different than if it were to be paved for an industrial park.

This report also provides guidance regarding economic development. Linking the report to economic development is important for two reasons. First, to facilitate major economic development, the site must decide on a primary future land use. Second, many of the supporting future land use activities are in the economic development realm and cannot be implemented until future use decisions are made.

The report should be read in the context of other future use efforts, most notably the site Future Use Project Report and the future use recommendations being prepared by the SRS Citizens Advisory Board (CAB). DOE Headquarters has charged each site to prepare a future use report that depicts stakeholder preferences for future use, given each site's unique characteristics.

While the major goal of this report is to provide recommendations for future SRS land use, land use recommendations will also help DOE decide suitable activities which are compatible with and support the primary use. Both the opportunities and limitations of the land and facilities at SRS have been considered in arriving at the recommended primary future use and ancillary activities (e.g., the National Environmental Research Park program, education, etc.). While the Land Use Technical Committee recommends that all land on the site remain under federal ownership, some of the land could be used by the public or private sector in a lease arrangement with the federal government. Because many site areas are suitable for multiple uses, the LUTC did not propose specific areas for specific uses. Specific uses and activities for site areas will be decided via established site policy and internal regulatory processes for site use.

The Savannah River Site

The 198,000-acre site contains four "shut-down" nuclear production reactors, one reactor in "cold-standby", two chemical separations areas, a fuel and target fabrication facility, a heavy water extraction plant, a defense waste processing facility, a saltstone waste facility, waste management areas, and various supporting facilities. These facilities extend over approximately 17,000 acres. The remaining 181,000 acres is largely forested and is used as a safety and security buffer zone for the production areas. This buffer zone provides valuable habitat for plant and animal species native to South Carolina, a protected area to conduct ecological research, and a large land expanse for timber production. SRS provides high quality wetland and wildlife habitat within a surrounding matrix of private agricultural and timber land. Wildlife is abundant and several endangered species populations are increasing as a result of the work funded by DOE and performed by the Savannah River Ecology Laboratory (SREL) of the University of Georgia, Westinghouse Savannah River Company (WSRC), and Savannah River Forest Station (SRFS) of the U.S. Forest Service (USFS) with support from state and federal wildlife agencies. Controlled public hunting is conducted on over 90 percent of SRS for both recreation and herd control. Additionally, SRS is an important National Environmental Research Park - a unique outdoor laboratory where research is carried out to achieve national environmental goals.

SRS was constructed from 1950-1955 to support the U. S. nuclear weapons program. Production of nuclear materials (tritium, uranium, plutonium, and various other elements) in a safe and secure manner in support of our nation's defense was the primary mission of SRS. In support of this mission, the site designed, constructed, and operated a wide variety of industrial facilities to manufacture nuclear materials. The industrial processes utilized include heavy water production, alloying, extrusion, and machining of metal alloy fuel and targets; irradiation of materials in nuclear reactors; chemical separation of desirable isotopes using remote operation technology; and other chemical and mechanical processes to form products and manage wastes. This wide range of industrial processes was augmented by support facilities for research, development, administration, and infrastructure, and includes laboratories, power plants, water treatment plants, fire stations and office buildings.

The tritium recycling mission, modified by anticipated program changes, will continue at SRS. Tritium activities include recycling of the active stockpile and extraction of tritium from remaining irradiated targets. Also continuing are the missions of environmental restoration and waste management.

The 40+ years of rapid-pace nuclear production has taken its environmental toll. The WSRC Environmental Restoration Division estimates SRS environmental clean up ranges from $4.7 to $10.2 billion (depending on the chosen land use scenario). This does not include the "D & D" (Decontamination & Decommissioning) costs associated with 212 contaminated facilities. As traditional DOE production missions are terminated with the end of the Cold War, the site workforce is being significantly reduced. This has affected land use in many ways, such as re-alignment of infrastructure support, "privatization" of facilities, increased public access and possible expansion of the site's ecological research.

SRS has been a leader in the application of technology. Much of SRS' success in technology demonstration and the field application of research has come in the environmental arena. SRS scientists and engineers have been studying the effects of contamination since before construction began in 1950; and new methods of environmental remediation have been successfully field-tested at actual sites at SRS.

In 1972, the National Environmental Research Park (NERP) system was established by the Atomic Energy Commission to make available large areas of ecological variety for the purpose of environmental research. SRS was named the first NERP in 1972. Under this program, scientific investigators from universities and other research organizations use SRS as an outdoor laboratory to study the impact of man's activities on the environment. Specific DOE Headquarters' guidance defines a NERP as "a field laboratory set aside for conducting ecological research, studying environmental impacts of energy development and informing the public of environmental and land use options."

For any future use plan, SRS should concentrate on its strengths, such as the size of the land area, its NERP designation, and its history of successes in the demonstration of technologies. In this time of transition, SRS is working with industry, academia, and government and has been striving to be a leader and partner in developing and exchanging applied science and technology to support SRS missions, enhance industrial competitiveness, and serve public needs.

Policy Guidance, Plans and DOE Orders

Possible future use options at SRS will be subject to administrative constraints stemming from federal, state and local laws, regulations, permits, and agreements. In addition, Department Orders, policy, guidelines, directives, and mission plans could also affect future uses. Under the National Environmental Policy Act (NEPA), RCRA, CERCLA and other statutes, DOE must consider the ecological health and ultimate fate of its natural resources in its future land use planning. Those resources will be affected by waste management, environmental remediation, future missions and D&D activities aimed at alternative land use activities. DOE is liable for damages resulting from CERCLA releases of contaminants at SRS.

CERCLA is a driving force for most SRS remediation activities. The Environmental Protection Agency (EPA) has, in the past, assumed under CERCLA that land will become residential in the future unless it is in areas where residential land use is unreasonable. Consequently, this requirement implies that the clean-up standard for contaminated waste sites is residential. Residential standards assume that a family would live on the land, obtain their drinking water from a well dug at the site, and children would play in the dirt and eat it. In a land use planning sense, this scenario is unrealistic and unreasonable for sites with a continuing federal mission managed by DOE with stringent safety and security measures. To support this view, EPA recently issued new guidance on land use in the CERCLA Remedy Selection Process (OSWER Directive No. 9355.7-04). In this directive, EPA stated that the CERCLA baseline risk assessment "generally needs only to consider the reasonably anticipated future land use." This new guidance supports the Land Use Technical Committee's recommendation that the site's primary future land use remain industrial and that no residential uses be considered.

The DOE's environmental management policy has been developed in response to mandates from the U.S. Congress under the National Environmental Policy Act of 1969 (NEPA), to protect the ecosystem processes and achieve environmental quality. NEPA subsection 101(a) states that the Federal government shall "use all practical means and measures...to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans."

Lesser known but equally important statutes govern SRS land use. Acts such as the American Indian Religious Freedom Act, National Historic Preservation Act, and Archaeological and Historic Preservation Act may constrain site uses. These acts direct federal departments and agencies to evaluate their policies and procedures in order to determine appropriate changes necessary to protect and preserve Native American religious cultural rights and practices.

"Ecosystem Management" is a federal program to which DOE-SR ascribes. Ecosystem management has been defined a variety of ways. Principles common to most definitions include: (1) integration of ecological, economic, and social factors, (2) maintenance and restoration of healthy ecosystems, (3) enhancement of biodiversity, (4) restoration of the original ecosystems, (5) long range planning, (6) landscape scale planning, and (7) incorporation of the human component. In short, ecosystem management means integration of ecological, economic, and social factors in order to maintain and enhance the quality of the environment to best meet current and future needs.

DISCUSSION OF PRIMARY FUTURE LAND USE CATEGORY

Below is a discussion of the primary future land use category proposed by the LUTC. Narrative is provided in lieu of maps because much of the site could be used concurrently by compatible activities, and hence, is not readily subject to mapping. While planning is useful in siting new facilities, the actual decision to site specific uses is a function of the established SRS site use process involving all SRS organizations.

Industrial

The primary industrial future use for SRS relates to stabilization and preparation for disposal of high and low-level wastes, managing surplus nuclear materials and support of the nation's nuclear weapons stockpile. In addition, related non-nuclear industrial missions would be able to utilize the unique infrastructure developed over the past forty-five years. Nuclear missions include tritium production facilities, tritium recycle facilities, and possibly weapons fabrication, storage, and maintenance. With its existing tritium capability, SRS is uniquely capable of supporting virtually all aspects of nuclear weapons stockpile maintenance. The site is one of the few areas in the nation that can support future missions with a combination of extensive industrial production areas, existing infrastructure, and a substantial buffer zone from the public. Other future uses involve alternative uses for the facilities that remain, and include metal-forming operations, storage of materials requiring high security, interim waste storage and technology development. Alternative land uses may include both commercial and governmental industrial activities. Some of the existing and potential future government missions for the SRS nuclear industrial areas are included in the following:

1) the stabilization of site nuclear material inventories, including the processing of fuels and plutonium residues;
2) the treatment of DOE spent fuels (including foreign fuels) and residues;
3) the de-militarization and storage of surplus plutonium pits with international surveillance and with potential interim immobilization as a vitrified form;
4) plutonium disposition preparation of disposable form or MOX (mixed oxide) fuel;
5) support of fusion research, including International Thermonuclear Experimental Reactor (ITER) fusion energy demonstration:
6) "blend-down" of surplus highly enriched uranium for commercial use, either as uranium or mixed plutonium/uranium fuel;
7) tritium production (accelerator or reactor technology) and recycling;
8) defense production (new pits);
9) commercial spent fuel management, potentially to include reprocessing;
10) regional energy park with siting of multiple commercial units and closed loop fuel with MOX fuels; and
11) decontamination/decommissioning and environmental restoration programs.

Besides governmental nuclear uses, future industrial uses of the site could also include commercial industrial development. While specific industrial endeavors are still being examined, general areas could include the following:

1) robotics technology development;
2) power generation;
3) state-of-the-art groundwater technologies development;
4) forest products development and production ;
5) aquaculture;
6) improved concrete production technology;
7) "washing" of contaminated soils; and
8) industrial metal works.

Also, technology demonstration would be compatible with industrial areas. Most technology demonstration projects are associated with industrial areas, cleaning up contamination in soils and water (surface and groundwater). SRS technologists have a solid national record of technology development and demonstration.

DISCUSSION OF LAND USE ACTIVITIES COMPATIBLE WITH INDUSTRIAL USE

The following activities are considered to be compatible with an industrial land use at SRS.

Environmental and Geological Research

Environmental and geologic research has been performed principally by SREL, Westinghouse's Savannah River Technology Center (SRTC), the SRFS and University of South Carolina's Institute of Archaeology and Anthropology Research Program. Scientists from other organizations have conducted studies in cooperation with these groups and/or under the auspices of the SRS NERP.

SRS facilities and their operation afford opportunities for conducting ecological research on interactions between industrial activities and the natural environment. Large portions of SRS are not directly affected by DOE operations (e.g., buffer and security areas). These areas are managed by the SRFS and are used for research purposes by the Forest Service and its 13 co-operating universities, the SREL, and Westinghouse Savannah River Company (WSRC). The unique configuration of the SRS, with laboratories and controlled field environments, allows scientists and engineers to take laboratory scale technologies into the field for evaluation and testing. SREL generates about 150 technical publications per year associated with the effects of site operations on ecosystems. The SRTC is the site's applied research and development laboratory. Examples of SRS research include remote radiological and non-radiological sensor technologies, robotics, and development of improved technologies for remediation of environmental contaminants.

Natural Resource Management

SRS contains extensive, widely distributed wetlands, most of which are associated with floodplains, Carolina bays, creeks, and impoundments. The southwestern boundary of SRS adjoins 17 miles of the Savannah River, which has a floodplain supporting an extensive swamp forest. The base floodplain of 37,128 acres is associated primarily with the Savannah River and five principal streams that drain the SRS. Nearly half the base floodplain is adjacent to the Savannah River. Many wetland communities occur within the floodplains, but others, such as Carolina bays, are isolated from river and stream interactions.

A diversified and abundant wildlife population including insects, fish, amphibians, reptiles, birds and mammals inhabit SRS. The site also serves as a refuge for the federally endangered red-cockaded woodpecker, short nosed sturgeon, wood stork, and smooth purple coneflower and the threatened American Bald Eagle. Scientists at SREL and the SRFS conduct research on these species. In addition to administering the threatened and endangered species program, the SRFS oversees timber management through its natural resources management program.

Cultural Resource Management

The cultural materials of previous occupants of the SRS are abundantly scattered throughout the site and are important to the national heritage and culture. The Savannah River Archaeological Research Program (SRARP) of the South Carolina Institute of Archaeology and Anthropology, University of South Carolina, began in 1973 with a "phased approach" with reconnaissance surveys, general intensive watershed surveys, and data recovery (excavation). The SRARP has recorded more than 1,000 archaeological sites - the largest archaeological investigation in the region.

Recreation

SRS' visitors program offers site tours and recreational sites for non-exclusive use by area organizations. Controlled hunting for large game animals (such as deer and feral hogs) is allowed on SRS. For most of the site's existence, recreation by the public was considered to be too much of a safety and security risk, and therefore was not advocated. With this policy in place, the deer population grew from a few dozen in 1951 to 5,000 in the 1970s. As a result of the increased deer population and an increase in site work force automobile/deer accidents grew at an alarming rate. To control the rising numbers of deer and subsequently to reduce the number of deer/automobile accidents, public hunting was introduced on the SRS. WSRC conducts 14 controlled deer hunts annually which cover the entire site. Another hunt conducted at SRS is administered by South Carolina Department of Natural Resources and involves approximately 10,000 acres designated as the Crackerneck Game Management Area. Except for Crackerneck Game Management Area, all large game taken from SRS are tested for possible radionuclide contamination.

As hunting has grown from herd control to recreation, site organizations have slowly increased recreational activities. Recent mission changes have allowed recreational additions to include improved "wellness facilities," such as running tracks and walking trails. The SRFS Forest Manager is charged with planning and directing a visual and wellness facilities management program that includes planning, development, and maintenance of on-site wellness facilities and improvement of the visual qualities of SRS forest lands. At present, these facilities are only for the use of SRS employees.

Public Education

In 1994, 4,500 people visited SRS through WSRC's outreach program which responds to requesters' needs for information, tours, data and seminars. One hundred and fifty tours of SRS in 1994 had participation from schools, senior citizens groups, civic organizations, environmental groups and others.

SRS also has an active technical educational outreach program. This program uses hundreds of scientists and engineers who volunteer their time and talents judging science fairs, speaking to area schools during Engineers' Week and representing their universities at yearly college fairs. There are also programs for college and high school interns and teachers to work with SRS scientists and engineers on environmental, natural resource and engineering issues. SRS has designated land that is used for a regional Boy Scout Camporee. Hundreds of Boy Scouts from the surrounding area meet at SRS every two years for their camporee. Site personnel provide classes on ecology, environment, forest management, wildlife management, water resources and archaeology. There is also a proposal underway to establish a similar program for the Girl Scouts. The youth education program provides a "classroom" at SRS to study engineering, science and natural resources. Any local class can attend a particular session at SRS provided by the SRFS. Teachers and lesson plans are also provided, with the average session taking requiring three visits to the site. In the first year of the program (1994) over 3,000 students participated.

The SREL has recently built a conference facility which is on-site but outside the general site fence. This allows for greater access by "uncleared" visitors. The conference center is the focus of scientific meetings, site tours and environmental instruction. SREL also sponsors "Ecocamps" and a "Saturday Morning Seminar Series.

LAND USE TECHNICAL COMMITTEE'S CONCEPT OF FUTURE USE OF SRS

Multiple and Compatible Uses

SRS has informally used a classic ring or "target" approach to land use planning with the center ring being an industrial area, and other areas being security and/or safety buffers. The guiding principle of the "inner ring" concept is the desire to locate all facilities which handle or process radioactive materials within the inner ring. Facilities outside the inner ring would ultimately be decommissioned or relocated. The SRFS has used this planning concept in its program to establish red cockaded woodpecker (RCW) habitats onsite. Human-induced habitats are promoted in the periphery of the site. However, in the industrial core, establishment of man-made RCW habitats is discouraged.

To understand the LUTC's future use recommendations, one has to understand multiple use. In this land use planning concept, several (or many) compatible uses and activities can "occupy" or use the same space simultaneously. Multiple use management focuses on optimizing the functions of the entire ecosystem. Although SRS is not a "community" per se, it can still utilize the multiple use planning concept. Consequently, an analysis of use compatibility has been prepared for the site in the form of the matrix below.

PRIMARY FUTURE USE	Current Acreage (Approximate)	Potential Acreage in 30 Years
Industrial	17,000 (developed)	50,000 (developed)
CONCURRENT SRS FUTURE ACTIVITIES		
Most Compatible Activities	Current Acreage (Approximate)	Potential Acreage in 30 Years
Research & Technology Demonstration	50,000	180,000
Public Education	50,000	180,000
Recreation	4,800	130,000
Natural Resource Management	180,000	180,000
Cultural Resource Management	180,000	160,000 (reduction occurs as more sites are characterized)

The aggregate of the categories in the matrix equal more than the site's total acreage of 198,000 because of the Land Use Technical Committee's recommendation for multiple uses occupying the same area.

LAND USE TECHNICAL COMMITTEE RECOMMENDATIONS FOR FUTURE USE OF SRS

Based on the summary in the preceding pages, the following recommendations are presented with supporting information.

Recommendation One - *Industrial as the Primary Use*

SRS boundaries should not change and the primary future land use should continue to be industrial, with multiple, concurrent supporting land use activities.

It is proposed that industrial uses of the site continue as in the past, with emphasis on stabilization activities of surplus materials and facilities. However, the *percentages* of land used for particular activities may change (current percentages are 15% developed and 85% undeveloped land). There are many reasons for maintaining site boundaries. Except for inquiries from former site residents, there appears to be no public demand for SRS land. This has been substantiated in numerous public meetings, where site planners heard no outcry for the commercial or developmental use of the land or facilities at SRS. However, local chambers of commerce and civic organizations have stressed that the site remain open to undertake industrial activities.

Also, although contamination is not severe, (given the size of the site), it is dispersed, being spread throughout much of the site, thus rendering not only the contaminated areas, but also those in-between, incompatible with public transference. Additionally, regulators have indicated they would oppose any move to release land that had not been cleaned up to residential standards.

Finally, for forty-five years the site has demonstrated that many diverse activities can coexist with each activity performing to its full potential. Eliminating federal ownership would have a significant effect on these relationships and eliminate some of these uses altogether. There are other reasons for keeping the site intact. These reasons are identified below.

Possible future national need for federal activities

Uncertainties in the world situation indicate that there is a need for some type of large, secure, government facility which could respond to a currently unknown threat. Although the exact nature of the threat may not presently be known, history shows that such threats do occur and that the nation needs to be prepared. With the current "downsizing" program, many DOE and DOD sites have been eliminated, leaving planners fewer available large sites should the need arise.

SRS uniqueness

With SRS under federal control for almost fifty years, many unique features now exist that should be maintained. The USFS has created and enhanced habitat for threatened and endangered species. Beaver ponds and natural wetlands abound. Many of the site's 200+ unique Carolina bays have been allowed to regain their wetland value and function. The portion of Upper Three Runs Creek in the northern region of the site has been documented as having one of the highest levels of aquatic insect biodiversity of any stream in the world. Site impoundments and the Savannah River Swamp serve as wintering refuges and migration rest stops for waterfowl and also serve as nesting and foraging areas for bald eagles; endangered wood storks forage in the swamps. The SRS has the highest biodiversity of amphibians and reptiles of any area in the Southeast. Game species, such as deer and turkeys, are in abundance on the site; and turkeys from the SRS are used to restock other suitable habitats in South Carolina. Also, during this period of government protection, archaeological sites have been protected and large-scale, long-term ecological research has been undertaken. SRS plays an important regional role in maintaining and enhancing biodiversity and in providing critical habitat for plants and animals of the southeastern United States. Finally, SRS is unique as a well-established NERP, contributing valuable scientific information to the region and country.

The number, time frame and cost of studies prior to turnover.

The number, time frame, complexity and cost of required studies are major impediments to an SRS real estate turnover process. Experts at SRS have compiled a partial list of studies that would need to be undertaken prior to transferring land to non-federal entities. Some examples of these studies are included in the appendix.

Recommendation Two - *Environmental and Geological Research*

Consistent with designation of the site as a National Environmental Research Park, research and related technology demonstration activities should be increased

Good planning dictates that decision makers responsible for the defense sites "do what they do best" when considering future uses. SRS leads the DOE Complex in many areas: established as the first "NERP" in 1972; known throughout the DOE Complex as a leader in environmental remediation technologies; seen as a treasure trove of cultural information; the unique research conducted by the USFS and the reputations of the Savannah River Ecology Laboratory, the Savannah River Technology Center and the Savannah River Archaeological Research Program all contribute to the viability of potential future uses for SRS. However, these programs have a tenuous status. The NERP program, while recognized to have many benefits in the scientific and land use communities, is not legitimized by statute and hence could be eliminated. While technology transfer efforts are slowly coming to fruition, they are not sufficient to provide a new site mission to maintain the economic viability of the SRS in the near future. Archaeological and anthropological research is often conducted in a reactive mode - responding to the need to survey sites to ascertain their cultural significance prior to initiation of construction. The SRFS research is based on a funds available basis, and SREL and SRTC conduct research primarily in support of the site's nuclear/industrial mission.

As future land use questions are settled, many of the programs above will be stabilized. Research has indicated that if a more stabilized planning base existed, foundation, university and government funding support would be forthcoming. In addition to being geared predominately to the site's previous defense mission, the research and technology applications could expand to be applied to unexploited areas of study. Studies have indicated that the site is well suited for research in algaculture, aquaculture, medicine, (expanded) bioremediation, forest products, the fate and effects of contaminants in the environment and archaeology and cultural anthropology.

Recommendation Number Three - *Residential Use*

No area of the site should be designated as potential "residential" areas.

In addition to the explanations provided in Recommendation One, there are other reasons which preclude "residential" designation for SRS. First and foremost is the extent of contamination. While the most dangerous contamination is contained and is not a hazard to health, there are areas of the site where remediation cannot be accomplished with today's technology, would require unrealistic resources or would destroy valuable habitats. Most of these areas are water bodies. For example, much of the Savannah River Swamp is contaminated with low levels of cesium, many of the stream beds have unacceptable levels of heavy metals and radionuclides, groundwater under the industrial areas is contaminated, and the 2,640 acre PAR Pond benthos has unacceptable levels of cesium and mercury.

While the preponderance of the site land area is free of contamination, under a residential scenario many future residences potentially would be located near the many on-site water bodies. This could present a risk to full-time residents, no matter how slight and remote. To protect the public, each stream, lake and pond would have to be fenced and patrolled. Restricting access to these water bodies would create a checkerboard pattern of land use which would not be acceptable for residential, industrial or a NERP. Additionally, many research projects, technology demonstrations, meteorological towers and monitoring devices would need to be relocated or eliminated due to their proximity to residential areas and the potential vandalism that can occur in unsecured sites. Also, while there has been some interest in returning the SRS to its previous owners, there has been no appreciable demand for the land as has occurred at other federal facilities. Release of the land could have unexpected negative effects on CSRA land prices.

Finally, the institutional question of federal liability has not been determined. With the present situation of controlled access to and monitoring on the SRS, the government can be reasonably assured that the public and site workers will not be exposed to undue risks. However, if the site is opened to unrestricted public access, especially through the most open residential scenario, the question of the government's limit of liability will need to be determined. Because of this, any future, non-governmental uses should be implemented with requirements that the federal government maintain ownership responsibility and ultimate oversight of the SRS.

Recommendation Four - *Consideration of Risks* and Costs

Future use planning should consider the full range of risks and costs associated with remediation.

Because of the site's unique mix of contamination and the constraints surrounding remediation costs, there are limits on how much of the SRS can reasonably be remediated to regulatory-acceptable levels. Therefore, efforts should concentrate on containment and monitoring to protect public health and the environment and clean up of areas that may limit future land use activities. This is a strategy recommended in published reports by policy researchers at the University of

Tennessee, the Congressional Office of Technology Assessment and the Congressional Budget Office. In conjunction with this strategy, future land use planning should prioritize environmental remediation based on one specific type of land use (e.g., industrial) and supporting activities.

Recommendation Five - *Maintain Natural Resource Management*

Natural resource management activities should be maintained/increased.

Natural resource management activities have played and continue to play a significant role at SRS. These activities could be increased and not inhibit other possible future uses. In some cases increasing natural resource management would provide more enhancement for other proposed future uses. For example, using the present acreage of forested lands and the concept of multiple use management, additional opportunities can be created for recreation, educational, and research activities. Also, an increase in the endangered species population could allow for export of these species "banks" to other areas.

According to Georgia's Water Branch of the state Environmental Protection Division, there may be resource-limiting factors that would curtail industrial growth and encourage expanded resource management at SRS. The chief of the branch told a public meeting in Augusta in 1992 that there is very little assimilative capacity left in the Savannah River due to the number of industries and municipalities dumping waste into the river body. Consequently, keeping large areas such as SRS along the river in a relatively natural state would be an excellent idea - not only to preserve SRS' environmental integrity, but to allow for planned off-site river development.

Recommendation Six - *Cultural Resource Compliance Maintenance*

Cultural resource compliance activities should be maintained at current levels to ensure pro-active management.

The primary purpose of the Savannah River Archaeological Research Program (SRARP) of the University of South Carolina, is to provide DOE-SR with recommendations concerning the management of cultural resources so that DOE will be in compliance with federal laws and regulations. Because the proper management of these resources is dependent upon on-going research to assess archaeological site significance, SRARP began a phased approach to compliance in 1973 with a research program involving reconnaissance surveys, watershed surveys, project-specific surveys and data recovery projects (excavation). These archaeological activities, operating in close coordination with major land users, facilitate the identification and preservation of cultural resources at SRS.

Through the integration of cultural resource management and research, SRARP acquires new knowledge about the past for dissemination to the local and national public and the professional archaeological community. In addition to their responsibility to DOE-SR, the missions of SRARP form the foundation for the decision process with many stakeholder groups. Cultural research provides background data for former land owners and Native American constituencies and assists local planners in their comprehensive planning. Cultural resource management activities should continue to focus on: 1) research-based compliance to ensure pro-active management, and 2) the dissemination of new knowledge to the public.

Recommendation Seven - *Increase Compatible Recreation*

Specific recreation activities compatible with other site uses and activities should be increased.

Several large tracts of SRS may be suitable for low impact, controlled, outdoor public activities such as hunting, hiking, bird watching, camping, and bicycling without impacting the industrial missions of the site. Also, with controlled access, other uses could continue unaffected by the increased recreational population. Controlled access would continue to ensure the safety of the public and, in the case of hunting, assure monitoring of game.

Recommendation Eight - *Increase Education*

Public education activities should be significantly increased.

Public educational activities could be greatly expanded without jeopardizing current or future industrial missions. Expansion of public education activities, advocated by many groups, would meld well with other concurrent uses. Increasing these activities has received support from the South Carolina Department of Parks, Recreation and Tourism, the [old] Ellenton Reunion Committee, the U. S. Forest Service, planners preparing the South Carolina Heritage Corridor plan, and various local planning and economic development organizations. Recently, various task groups have been exploring the feasibility of establishing a museum/education/interpretive center on the site. The Land Use Technical Committee endorses this concept.

Recommendation Nine - *Establish a Land Use Decision Process*

Additional mechanisms should be established to assist the DOE-SR Site Manager in the land use decision process.

DOE land and future use planning is undergoing change. New directives call for increased planning activities with expansion of input to assist the decision making process. One organizational approach for land use planning would be to expand the membership of the Land Use Steering Committee (presently consisting only of WSRC senior managers), creating a truly site-wide land use advisory committee consisting of experts from each major land use organization. This group would advise the DOE-SR Site Manager on the status of the current land uses, provide assistance in planning other land uses or expanding current uses, and provide expert judgment should land use conflicts arise. Concurrent with the establishment of this committee would be increased support, coordination and consolidation of site land use activities.

While important for future use planning, the establishment of use and activity zones were not considered in this report. Development of planning zones for compatible uses requires a large, concerted effort and is time-intensive. If SRS management wishes to pursue a zoning concept for future use planning, the LUTC would provide active support. Establishment of a decision hierarchy based on use-compatibility criteria and adherence to the multiple use concept would strengthen the land use decision process. The LUTC also strongly endorses establishment of use-compatibility criteria and would provide a lead technical role in such an endeavor.

CONCLUSION

In this report the SRS Land Use Technical Committee has used its cumulative knowledge to present a fair appraisal of future land use. While no one can predict the future, the LUTC has provided its best judgment on the utilization of site attributes which will most wisely use the physical and natural resources of SRS. What the committee envisions are expanded site functions that are dynamic and meet the needs of the country while still responding to concerns of the region. From a land use perspective, all site activities could be expanded. The committee believes that a site as unique and large as SRS can also meet the needs of diverse interest groups. SRS' natural, industrial, cultural and demographic resources are indeed a treasure that should be preserved.

EXAMPLES OF REQUIRED STUDIES PRIOR TO TURNOVER OF FEDERAL LANDS

National Environmental Research Park (NERP) Status - Although SRS was designated the first NERP in 1972, it has no legal status as such and could be "undesignated" quite easily. Consequently, elimination of the NERP program would not require studies. However, the 30 NERP "set-aside" areas may require study to determine their ecological value and, if necessary, what protective steps could be taken to ensure their continued existence in a protected status. An option which DOE-SR is currently pursuing is having the NERP designation institutionalized via federal legislation.

Transportation - A detailed study would need to be completed to fully determine the impacts that opening the site would have on U. S. Department of Transportation compliance. These studies include adequacy of bridge and road bed load capacity, hazardous waste transportation, traffic flow and intersection safety. Site transportation planners estimate that the increased transportation costs could amount to an additional $3 million per year in operating costs and as much as $38 million in one-time expenses. The time to implement these changes, from the initial study phase through implementation would be from 3 to 20 years.

Threatened and Endangered Species - Although much of the site has been surveyed for threatened and endangered (T&E) species, a complete site inventory of T&E species would need to be completed. Because the SRS T&E species are federally protected, consultation with the U. S. Fish & Wildlife Service would be required. In the past, these studies have cost $70 per acre. However, because of the opportunity for economy of scale provided by SRS' 198,000 acres, SRFS planners estimate the cost of the inventory process could be as low as $3-10 per acre.

Cultural and Archaeological Heritage - Several federal statutes are quite explicit as to the responsibilities of federal agencies in this area. Studies are required prior to transfer of federal land (e.g., National Historic Preservation Act, Archaeological and Historic Preservation Act and the American Indian Religious Freedom Act). The time and money involved in the turnover process depends on a range of variables, including: size of survey area, archaeological sensitivity zones represented, intensity of survey and site testing, number and complexity of sites, and, if appropriate, the level of data recovery for the significant resources. Since no comparable government site this large has been intensively surveyed before, only extrapolation of cost and time factors can be used. If siting the New Production Reactor is used as a baseline, the cost would be $90 million. Again, due to economies of scale, it could be assumed the cost and time factor would be lower.

Safety Analysis Reports (SARs) - The impact and risks from potential accidents at SRS nuclear facilities are analyzed in formal "Safety Analysis Reports" (SARs). Each of the twenty-four nuclear facilities has a SAR. These reports describe each facility and its operations with special emphasis on safety features. The reports also consider all possible accidents and analyze the risk to site workers and the general public in the site vicinity. Since SARs are based on the current site boundary they would need to be revised if the boundary is changed. Costs per SAR for an individual facility range from ten thousand dollars to hundreds of thousands of dollars. The higher costs would accrue if boundary changes are at locations of the highest consequences from potential accidents.

National Environmental Policy Act (NEPA) Review - If a land transfer were to occur, it would constitute "a major federal action," and the NEPA process would be in effect. However, there are many variables associated with this process; the most important variable being the future use of the land. If the future use is not significantly different than the historic DOE use, then a "Categorical Exclusion" (CX), the lowest NEPA requirement, would be required. However, if there was a significant change in future use or if the site boundaries changed as in the SAR example above, then an environmental impact statement (EIS) would be required. An EIS can cost $2 million over 2 years.

Findings of Suitability for Transfer - The Community Environmental Response Facilitation Act (CERFA), National Defense Authorization Act (FY 94) and the "Hall Amendment" (Public Law 103-160) govern transfer of public land. The most important requirement of these statutes is that an "Environmental Baseline Survey" (EBS) must be completed prior to land or facility transfer. The survey identifies property on which hazardous substances, petroleum or their derivatives were stored, released or disposed. The results of these surveys must be approved by the EPA Administrator with concurrence by the State of South Carolina. Based on an EBS of D Area, it is estimated that two months or more study time would be required for each of the 15 major site areas.

Monitoring - Prior to transfer, various sampling regimens would need to be completed and an ongoing sampling program initiated. Monitoring of the air, surface water and groundwater, regardless of future use, would have to be continued, and in some cases, expanded. Costs cannot be determined at present due to the uncertainty of property location, size and possible contamination.

Mapping - Subdividing parcels of SRS real estate for transfer would require extensive surveys. Since the land has not been publicly occupied since the early 1950's, existing parcel boundaries and corresponding monuments do not exist. Site surveyors estimate mapping would cost $500 per acre.

Security - Wackenhut Services, Inc. has indicated that if site boundaries change significantly and/or a large number of guard posts are eliminated or re-located, additional security studies would be required to ensure the security of the site's classified missions, employee/public safety, and protection of DOE's assets would remain at acceptable levels. To date, no cost or time estimate of this task has been made.

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Appendix E SRS Future Use Project Team

Don Druelle, DOE-SR Project Team Leader
Gerri Flemming, DOE-SR
Virginia Gardner, DOE-SR
Jerry Nelsen, DOE-SR
Rick Ford, DOE-SR
Gail Jernigan, WSRC
Robert Meadors, WSRC
Chris Noah, WSRC

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Appendix F Organizations

The following organizations expressed an interest in the SRS Future Use Project by having a Future Use Project Team member speak at a meeting, by attending a SRS public meeting on the Future Use Project, or by providing written or verbal comments on recommendations or the process for the Future Use Project. Summaries of the recommendations from the SRS Citizens Advisory Board, Citizens for Environmental Justice, and the SRS Land Use Technical Committee are in Section 2; the full text from these groups are in the appendices.

Aiken Lions Club, Aiken, SC
Aiken Midday Lions Club, Aiken, SC
Augusta Retail Credit Association, Augusta, GA
Barnwell Lions Club, Barnwell, SC
Citizens for Environmental Justice, Savannah, GA
Citizens for Nuclear Technology Awareness, Columbia, SC
Ellenton Reunion
Energy Research Foundation, Columbia, SC
Hyde Park community group, Augusta, GA
Lower Savannah Council of Governments, Aiken, SC
National Association for the Advancement of Colored People (NAACP), Aiken, SC
National Turkey Federation, Edgefield, SC
Savannah River Site Citizens Advisory Board (SRS CAB)
Savannah River Regional Diversification Initiative (SRRDI)
Savannah River Site Citizens Advisory Board
Savannah River Site Land Use Technical Committee (LUTC)
Sierra Club, Augusta, GA
South Carolina Department of Natural Resources, Columbia, SC
South Carolina Quail Unlimited, Columbia, SC
St. John's Methodist Church, Aiken, SC

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Appendix G Summary of Public Meetings

This appendix is a summary of the six public meetings held by the Department of Energy on the issue of future use. Except for the September 19, 1994, public meeting, these meetings were also co-sponsored by the Risk Management and Future Use Subcommittee of the SRS Citizens Advisory Board. The November 1, 1994, meeting was also co-sponsored by the Savannah River Site Diversification Initiative.

While not all comments have been listed in this appendix, the essence of the comments has been shown below.

September 19, 1994, Public Meeting in Aiken, South Carolina

The purposes of this meeting were to: (1) present the *Draft Current Land-Use Baseline Report* to stakeholders, (2) discuss the future use planning process and receive stakeholder input, and (3) obtain stakeholder input on the method and degree of public participation in the development of SRS future-use recommendations. The meeting was held from 6:00 p.m. to 9:00 at the Stevenson-McClelland Building in Aiken, South Carolina, and approximately 60 people attended.

Bill Noll, (the Deputy Assistant Manager for Engineering and Projects for Department of Energy Savannah River Operations Office [DOE-SR]) provided an overview of the Future Use Project. Ernie Chaput, Deputy Manager for DOE-SR, introduced the topic, specifically, "How do the various stakeholders, both groups and individuals, want to interact with the Department of Energy (DOE) on the future use of SRS as a resource of the U. S. Government?"

The purpose of the Future Use Project was defined as a process to produce stakeholder-preferred future use recommendations for SRS by September 1995, where these recommendations will be used to aid DOE's decision-making. This process was not to develop missions for DOE at SRS. The stakeholder-preferred recommendations may be used by:

- defining "how clean is clean" for site planning activities,
  - waste cleanup goals
  - decontamination and decommissioning goals
- developing economic opportunities by potential re-use of surplus land and facilities, and
- planning for site development and future land use and determining the level of infrastructure maintenance necessary to implement these plans.

Future use decisions will be based on stakeholder-preferred uses, technical considerations, legal constraints, and DOE mission requirements.

The participants were divided into four different groups and each group was given the same discussion topic: to discuss how the public should be involved in the process. Ideas from the breakout sessions included the following:

- DOE should provide a strawman and guidelines for the Future Use Project process and for the public participation plan. Stakeholders want to become involved, want to be heard, and want to be active in this process.

- The SRS Citizens Advisory Board (CAB) should be the primary focus for stakeholder involvement; others disagreed. Those who believed that the CAB should be the focus of the project thought that a consensus could be developed by using this method.
- Regulator involvement (South Carolina Department of Health and Environmental Control and the Environmental Protection Agency) is necessary for the success of this project.
- Organizational stakeholders could submit reports from their own subcommittees. (Organizational stakeholders suggested were schools, National Association for the Advancement of Colored People [NAACP], chambers of commerce, the University of South Carolina at Aiken, etc.) These organizational stakeholders could attend CAB meetings and members of the CAB could attend organizational stakeholders' meetings.
- Meetings should be focused and organized with defined deliverables and agendas. This information should be sent to participants prior to any public meeting so that participants can come prepared.
- Participants want a written summary of all meetings.
- Environmental Impact Statements could provide some guidelines for future missions and direction for the site.
- Open public meetings and working in subcommittees and with the SRS CAB were the best approaches for public involvement in the Future Use Project process.
- Participants should be "educated" about the Savannah River Site and the Future Use Project. Suggested sources included the *Savannah River Operations Strategic Plan*, the *Land-Use Baseline Report*, SRS fact sheets, other DOE field offices' experience in the Future Use Project process, and a designated point of contact.

Don Druelle was announced as the DOE point of contact.

November 1, 1994, Public Meeting in North Augusta, South Carolina

The objectives of this meeting were to provide information through presentations and discussions to interested citizens on the *Draft FY 1995 Current Land Use Baseline Report*, the *Savannah River Operations Office's Strategic Plan*, and proposed process for developing stakeholder-preferred future use recommendations. The meeting was held from 4:00 p.m. to 7:00 p.m. at the North Augusta Community Center with approximately 60 people attending.

Lee Watkins, the DOE-SR Assistant Manager for Engineering and Projects, opened the meeting with introductions and a review of the meeting agenda. Robert Meadors, Westinghouse Savannah River Company Strategic Programs and Planning Department, discussed the *Draft FY 1994 Current Land Use Baseline Report* including the purpose of the report, stakeholder participation, the goal and organization of the report, major mapping categories, and plans for the final report. He also announced that the final report would include health risk mapping and that comments on the *Current Land-Use Baseline Report* would be accepted through November.

Ernie Chaput discussed the *DOE Savannah River Operations Office Strategic Plan* regarding its implications on the Future Use Project. His presentation included the background of the *Strategic Plan*, its contents, impact, and the six business lines (Industrial Competitiveness, Energy Resources, Science and Technology, National Security, Environmental Quality, and

Infrastructure). This plan is a living document and will be updated periodically and comments would be accepted on this plan through January 1995.

Larry Synder presented information on the *Draft Public Participation Plan for the Future Use Project* including the proposed outline, process, and project steps. He also discussed the previous public meeting and how DOE had incorporated those comments in the proposed plan.

Comments from the public are shown below.

- The Metro-Augusta Chamber of Commerce advocated new missions for SRS and hoped that SRS is actively pursuing activities such as the ITER (International Thermonuclear Experimental Reactor), new tritium source for the nation, etc., and hoped that DOE would continue its technology transfer activities. SRS is the economic engine for the region.
- The Citizens for Nuclear Technology Awareness (CNTA) also supported new missions for SRS such as ITER, new tritium source, etc.
- The Savannah River Regional Diversification Initiative (SRRDI) believed that at least three areas should be given serious consideration in the development of future land use: environmental management, future defense missions, and industrial development. Consideration from economic and technology transfer perspective should be given to using the site's land and facilities as an asset for local development. SRRDI also would like to see the availability of the site's land and facilities on a lease basis for other industries.
- The Lower Savannah Council of Governments thought that this Future Use Project should continue to be an open process which would solicit comments from the various counties and municipalities in this region.
- The SRS Citizens Advisory Board strongly encouraged comments from the public since the CAB makes recommendations to DOE, the Environmental Protection Agency, and the South Carolina Department of Health and Environmental Control on the future use issue.
- The South Carolina Department of Commerce thought that there should be more technology transfer to private industry and stated that they planned to become more active in the future use planning process.

February 2, 1995, Public Meeting in Augusta, Georgia

The stated objectives of this public meeting were to: (1) provide an opportunity for public comment/discussion on the strawman *Draft Public Participation Plan for the Future Use Project.* (2) discuss the roles and responsibilities of the co-hosts for the meeting, (3) discuss the objectives of the Future Use Project, (4) present the Secretary's Land Use Initiative, and (5) by using a "brainstorming" technique, solicit potential future use options and begin to categorize according to industrial, recreational, resource management, etc. However, due to numerous comments from the audience, the brainstorming for potential future use options was done first, followed by comments on the *Draft Public Participation Plan for the Future Use Project.* The Secretary's Land Use Initiative was not discussed. The meeting was from 4:00 p.m. to 6:00 p.m. and approximately 75 people attended the meeting at the Augusta Richmond County Civic Center in Augusta, Georgia.

Brian Costner, chairman of the Risk Management and Future Use Subcommittee of the SRS CAB, provided a brief overview of the CAB and this subcommittee. Susan Payne provided a brief overview of SRRDI, a community reuse organization and its interest in the Future Use Project.

Below are some of the suggestions received during the brainstorming session of the meeting. This brainstorming session was to generate ideas for possible uses for the land and facilities at SRS. (See Appendix A for a summary of potential uses for land and facilities; this summary includes suggestions from public meetings, written comments, and other comments received by DOE.)

- The site is over 300 square miles; turn the uncontaminated land back to the counties from which it was taken and let them deal with it.
- Use only the industrial areas and leave the buffer zone as pristine sections. Do no use undeveloped land for new development.
- SRS is a unique place in that part of the land is contaminated and part of the land is pristine. This is not true of any other place or public land. Look at this unique combination and make this land a National Environmental Research Park. You can address many things by saving and using the contaminated areas as testing for future studies on the affect of radiation and future contamination research. This minimizes the costs and maximizes the information gained. Leave some contaminated land for future research.
- Maintain the site as a unit for potential future federal government purposes.
- Keep future land uses flexible.
- Keep the land for multiple uses, such as timber management, recreation, research, etc.
- Keep the site for ecological and environmental research.
- Keep the site as a research park with a mix of nuclear and non-nuclear uses.
- Use the facilities to process fissile material from commercial fuels.
- Maintain the site as an entity. Continue manufacturing with an environmental mix.
- The United States depends on foreign oil and energy. Presently 60% of our energy comes from foreign suppliers. SRS could be used for energy production, possibly nuclear energy.
- The site is a national asset and has interested parties across the United States, both economic and environmental.
- SRS is an ideal area for developing nuclear industrial research.

Below are some of the comments received on the *Draft Public Participation Plan for the Future Use Project.*

- How many more meetings with DOE hold without representation from the African-American community?
- DOE must consider environmental justice concerns.
- The documents that support this project are not written so that the average person can read and understand them. If you want real stakeholder involvement, you must give the public something they can use and understand.

- The survey in the *Draft Public Participation Plan* is poorly worded and does not ask good questions. There is value in a survey if it is done according to accepted practices. This survey does not meet objectivity. To get meaningful results, the survey must be credible.
- Need to keep a direct link between DOE and the public.
- Public comments should not be filtered through intermediaries such as SRRDI, CAB, etc.

[NOTE: Due to the numerous negative comments on the survey at the February 2 public meeting and other comments received by DOE, the survey was dropped from the public participation planning process.]

April 11, 1995, Public Meeting in Barnwell, South Carolina

The purpose of the meeting in Barnwell was to (1) provide background information on the Future Use Project including the status, purpose, and objectives of the project and (2) using a brainstorming technique, solicit potential future use options and begin to categorize them according to industrial, recreational, resource management, etc., land uses. The meeting was held at the Barnwell State Park from 6:00 p.m. to 9:00 p.m. and approximately 25 people attended.

Robert Meadors opened the meeting with a pre-meeting briefing. This presentation was prepared so that all participants attending these public meetings would receive the same information, regardless of the speaker. This presentation was also used at various civic clubs, churches, and other organizations who requested a speaker on this topic. The overview presentation briefly describes past and current land uses and missions at the Savannah River Site , discusses possible future land use categories such as industrial, agricultural, residential, environmental research, etc., and presents a Department of Energy perspective of the site's future.

Julie Arbogast, a representative of the SRS Citizens Advisory Board Subcommittee on Risk Management and Future Use, gave a brief background of the work this subcommittee is doing. The subcommittee plans to have a recommendation to the full Citizens Advisory Board in September for the members' consideration and a recommendation to the Department of Energy, the Environmental Protection Agency, and the South Carolina Department of Health and Environmental Control by December.

Below is a summary of comments received at the meeting.

- The land at SRS should be given back to the former residents of the area. My land was legally "stolen" from me in 1952 at $42 per acre.
- Mike Caudell, a biologist with the South Carolina Department of Natural Resources (DNR), read from a prepared letter requesting that all future use plans contain additional outdoor recreational opportunities for the general public. Specifically, DNR suggested diverse public hunting programs.
- As a member of the Barnwell County Council and the Citizens Advisory Board and a former resident of Ellenton with roots in Dunbarton, I do not wish to take the land back. I would like to visit the areas where I grew up and my family lived for many generations. I believe that recreational use of the land is a good idea and I do want to see a safe environment for all local

citizens. I also want to see our citizens employed and the facilities should be kept in use. This is an important program.

- John Edwards read a letter to Don Druelle, Project Team Leader, from James Earl Kennamer of the National Wild Turkey Federation. This letter encouraged hunting, fishing, and other outdoor activities at SRS where possible.
- Joe Hamilton from the South Carolina Department of Natural Resources spoke in favor of "quality deer management." Quality deer management strives to improve the quality of deer herds and deer hunting experiences through sound management of buck/doe ratio, buck age structure, and deer densities that are compatible with habitat conditions and land use objectives of landowners.
- A Ducks Unlimited representative spoke in favor of the Department of Natural Resources recommendations.
- The chairman of the Aiken Quail Hunters said that the cooperative agreement with the Forest Service and the Department of Natural Resources has been good for hunting and for our natural resources.

The participants in the meeting were also asked for criteria that decision makers should use in making decisions for the future use of land and facilities at SRS. Suggestions included:

- No one should get hurt from contamination at SRS.
- The land should stay set aside for national security.
- To avoid risk of exposure, the site should be kept intact until all cleanup work is complete.

May 3, 1995, Public Meeting in Beaufort, South Carolina

The objectives of the public meeting in Beaufort were (1) provide background information on the Future Use Project including the status, purpose, and objectives of the project, (2) using a brainstorming technique, solicit potential future use options and begin to categorize according to industrial, recreational, resource management, etc., and (3) solicit values from participants. The meeting was held at the Holiday Inn, Beaufort, South Carolina, from 4:00 p.m. to 7:00 p.m. with approximately 16 people in attendance.

Don Druelle opened the pre-meeting with the same overview that was used at the Barnwell, South Carolina, public meeting. After a brief break, the main portion of the meeting agenda was opened by Lee Watkins, the Assistant Manager for Engineering and Projects, who welcomed the participants to the meeting. Mr. Watkins explained that a strawman report will be prepared in June with additional public meetings on the strawman to be held in July.

Brian Costner discussed the work the CAB Subcommittee on Risk Management and Future Use is doing. This subcommittee plans to have a proposal for the full Citizens Advisory Board review in September as a recommendation to the Department of Energy, the Environmental Protection Agency, and the South Carolina Department of Health and Environmental Control. He explained, as an example, that it is estimated to cost $2 billion to drain Par Pond and dig up the contaminated sediments or it will cost $1 million per year to maintain the current water level at Par Pond. By maintaining the current water level, the water acts as a shield against radiation. However, if the $1 million option is chosen, the subcommittee would like assurances that this $1 million is available each year—for the next 50, 100, or 500 years. Existing conditions at SRS like Par Pond will determine the future use of the land and facilities. A member of the audience also asked about the risk benefit. For example, if Par Pond was dug up, this type of construction would probably result in 10-20 deaths of construction workers, whereas if the pond is left alone, we could save these lives.

Several citizens read prepared letters. These citizens are former residents of the land and would like the opportunity for first refusal if there is a chance that land would be returned to private ownership. They would like the chance to benefit from the sale of any land for privatization. Many believe that their heritage was taken from them in the early 1950s, as many displaced families had lived on this land for generations, dating back to the eighteenth century. Some have lost family cemetery plots and do not know where family members are currently buried.

Brian Costner suggested that a map showing former land ownership should be shown in the *Land Use Baseline Report* which is currently being prepared. He also suggested that former residents should meet with the Citizens Advisory Board and the CAB Subcommittee on Risk Management and Future Use.

The participants were asked for criteria DOE should use when making decision. Their answers included:

- fairness
- put your heart into it, not just financial gain
- reality
- who's most justified to use the land?
- consider people before wildlife and waterfowl
- give us a choice

May 4, 1995, Public Meeting in Savannah, Georgia

The next public meeting was held in the public library in Savannah, Georgia from 6:00 p.m. to 9:00 p.m. Because only one citizen came to the meeting in Savannah, the formal agenda was not used. Instead, a roundtable discussion was used to answer questions and provide information to this citizen. Don Druelle reviewed the purpose and status of the Future Use Project and Brian Costner explained the purpose of the CAB Subcommittee on Risk Management and Future Use. The participant was asked what criteria DOE should use when making decision. Her answer was "the water quality. The Savannah River and the quality of the groundwater is important to me and others in this area."

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Appendix H Relevant Maps From the SRS Land-Use Baseline Report

One of the comments we received on previous drafts of this report was to include the *SRS Land-Use Baseline Report* as one of the appendices in this report. Due to cost considerations, we were unable to use the entire report as an appendix; however, we have include some of the relevant maps in this appendix. Copies of the *SRS Land-Use Baseline Report* can be found in the Department of Energy Reading Room as shown below.

U. S. Department of Energy Public Reading Room
Gregg-Graniteville Library
University of South Carolina at Aiken
171 University Parkway
Aiken, South Carolina

Hours: Monday-Thursday, 8 a.m. to 11 p.m.
Friday, 8 a.m. to 5 p.m.
Saturday, 12 noon to 5 p.m.
Sunday, 2 p.m. to 11 p.m.

Administrative/Nonnuclear Facilities

Overview/Program Description

As of November 1995, SRS employees were housed in 96 administrative office facilities, 567 administrative trailers, and 9 off-site leased administrative facilities. The site's major contractor, WSRC, is responsible for the administration of office facilities and functions.

Office space consists of permanent buildings on site and permanent and temporary office trailers. The program for office space management also encompasses personnel relocation in facilities on and off site. Subcontracts provide janitorial, laundry, food services, pest control, termite treatment and general labor services sitewide to support administrative facilities.

The nonnuclear facilities include Central Shops (N Area), Heavy Water Area (D Area), and part of SRTC.

Purpose/Missions

Administrative Facilities

The administrative facilities provide office space, general training, and records storage for SRS personnel to conduct normal operations in support of the site's mission.

A Area and B Area are the primary administrative areas. A Area provides office space for 4,027 employees, and B Area provides office space for 885 employees. A Area houses DOE and WSRC senior management and other personnel and is the location of SREL and SRTC. B Area houses WSRC, DOE, and WSI personnel.

Administrative facilities also are located in each process area to provide office space for personnel who support the areas' specific functions.

Forty-three percent of the site's office buildings are more than 30 years old, 15 percent are from 10 to 29 years old, and 42 percent are less than 10 years old. Several modular facilities will be proposed during the next five years to facilitate the removal of on-site office trailers. A Area and B Area will be primary administrative areas. A sitewide training facility is scheduled for completion in H Area by fiscal year 1996.

Existing administrative space in production areas that are not scheduled for decontmination and decommissioning (D&D) and that have adequate infrastructure will continue to be utilized to meet overall housing needs. The existing facilities are expected to be well-maintained to extend their useful lives.

DOE's most recent priorities for providing administrative facilities are to

- relieve facilities that have serious, irreparable health and safety concerns
- eliminate off-site leased space
- eliminate on-site leased trailers
- relieve compression

Nonnuclear Facilities

Central Shops (N Area)

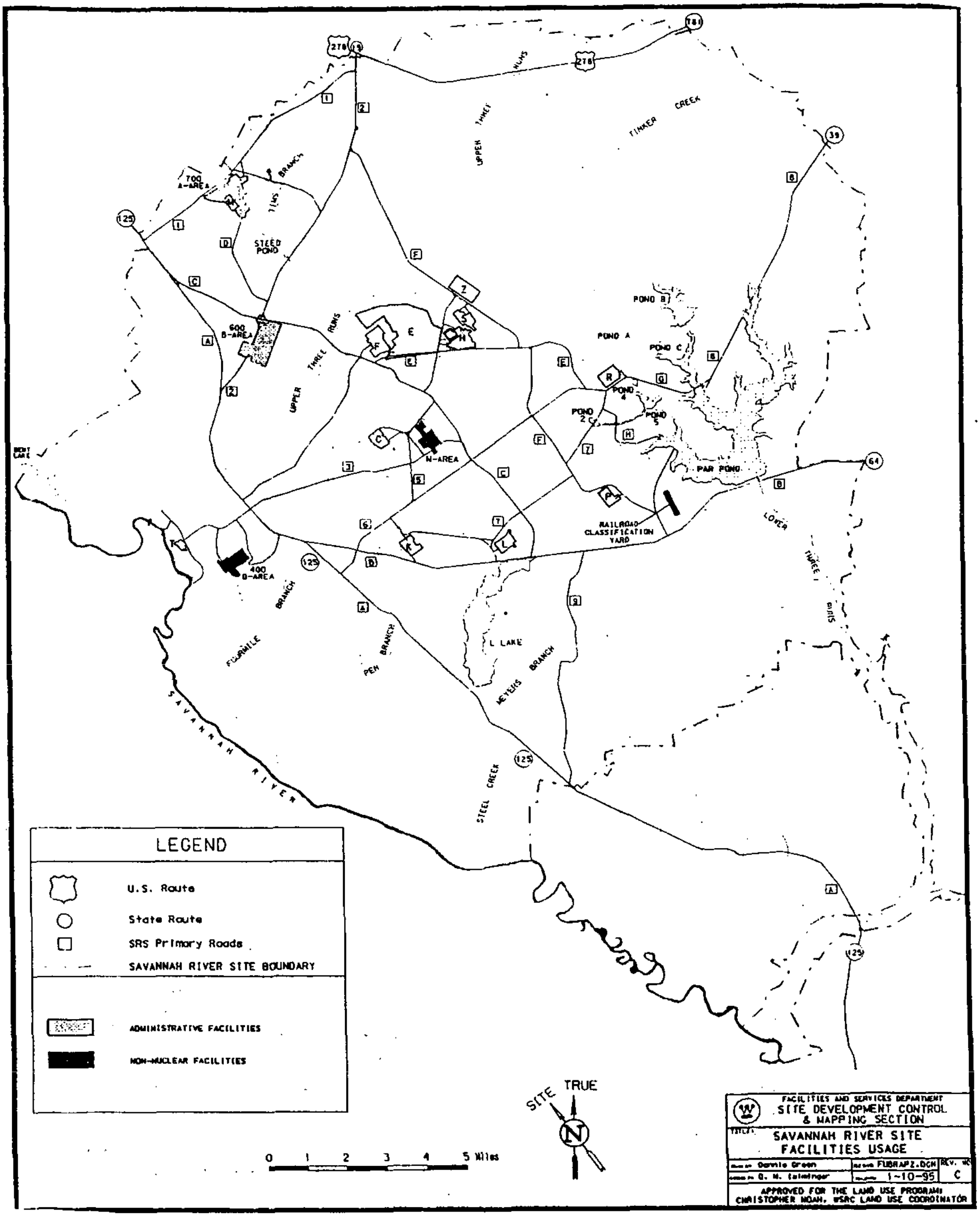
Central Shops (N Area) house construction and craft facilities, such as fabrication and welding shops, and associated materials in support of construction activities. This area also is the primary storage facility for operations and maintenance materials, including supplies and spare parts.

Heavy Water Area (D Area)

D Area actually is a "dual use" facility in that it has significant nuclear and nonnuclear operations. D Area contains facilities for supplying heavy water coolant/moderator to the reactors. Heavy water purification facilities, an analytical laboratory, and a powerhouse are operating in the area. D Area's mission will be the cleanup and concentration of the existing inventory of heavy water.

Savannah River Technology Center

SRTC conducts research, development, and technical support activities. Laboratory operations are conducted in the Technical Area (700) and the TNX Prototype Testing Area (600). SRTC also has nuclear facilities within the Technical Area. As an incentive to industry (1) to locate or expand operations within the local region and (2) to enhance technology transfer, a plan will be implemented to establish user facilities, thus serving a dual-use function that supports the SRS mission but is available to the private sector.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U.S. Route
State Route
SRS Primary Roads
SAVANNAH RIVER SITE BOUNDARY
ADMINISTRATIVE FACILITIES
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SITE DEVELOPMENT CONTROL
& MAPPING SECTION
SAVANNAH RIVER SITE
FACILITIES USAGE
1-10-95
APPROVED FOR THE LAND USE PROGRAM:
CHRISTOPHER NOAH, WSRC LAND USE COORDINATOR
700 A-AREA
STEED POND
600 B-AREA
UPPER THREE RUNS
TINKER CREEK
POND B
POND A
POND C
POND 4
POND 2
POND 5
PAR POND
N-AREA
RAILROAD CLASSIFICATION YARD
400 D-AREA
FOURMILE BRANCH
PEN BRANCH
L LAKE
MEYERS BRANCH
STEEL CREEK
LOWER THREE RUNS
SAVANNAH RIVER

Nuclear Industrial Facilities

Overview/Program Description

The nuclear industrial facilities at SRS are owned by DOE and operated and maintained by WSRC. The purpose of these facilities is to provide stabilized, secure storage and disposition of nuclear materials. Because a number of these facilities are no longer in use, SRS is developing D&D plans for the facilities' final disposition. These plans will include the numbers and locations of buildings, cost estimates, and health and safety considerations.

Purpose/Missions

Fuel/Target Fabrication (300 Area)

Metallurgical/foundry facilities for fabricating reactor fuel and target elements for SRS reactors are located in the 300 Area. An orderly phaseout of all production activities for reactor fuel and target manufacturing is occurring. Materials in the area are being processed for shipment to permanent storage sites or declared excess and disposed. Subsequently, the retired facilities will be transferred to the Facilities Transition Program and placed in a surveillance and maintenance mode pending D&D or reuse by commercial firms.

Nuclear Production Reactors (100 Area)

Five reactors for nuclear material production originally were built at SRS. All five reactors–C, K, L, P, and R–are now classified as surplus facilities. Fuel storage basins in L Reactor and P Reactor contain irradiated fuel and targets awaiting a decision on future disposition. K Reactor is in "cold standby." Future production of new tritium by a new reactor or accelerator is the subject of ongoing DOE studies.

Nuclear Materials Processing Facilities (200 Area)

The processing, stabilization, separation, and recovery of nuclear materials are performed in two main operating areas, 200-F and 200-H. Each has (1) a large shielded "canyon" building for processing irradiated materials, (2) glove box facilities for product finishing and plutonium residue processing, and (3) associated support facilities. In addition, F-Area contains an analytical laboratory, the Plutonium Metallurgical Building, and the Naval Fuel Facility (currently in standby). H Area contains the Receiving Basin for Offsite Fuel, which provides interim cooled storage for off-site spent fuels.

The nuclear materials management mission includes stabilization, secure storage, and disposition of the large quantities and various types of nuclear materials at SRS, as follows:

- Stabilize SRS nuclear materials for safe, secure storage and eventual disposition. Many activities are contingent upon the completion of pending National Environmental Policy Act (NEPA) actions.
- As required to implement preferred alternatives identified through an ongoing NEPA process, process or stabilize existing inventories of nuclear materials, including unstable spent fuels, to forms suitable for safe, secure storage for eventual disposition as waste or as usable materials (F Area/H Area).
- Receive and store off-site spent nuclear fuels contingent upon completion of appropriate NEPA requirements.

Tritium Facilities

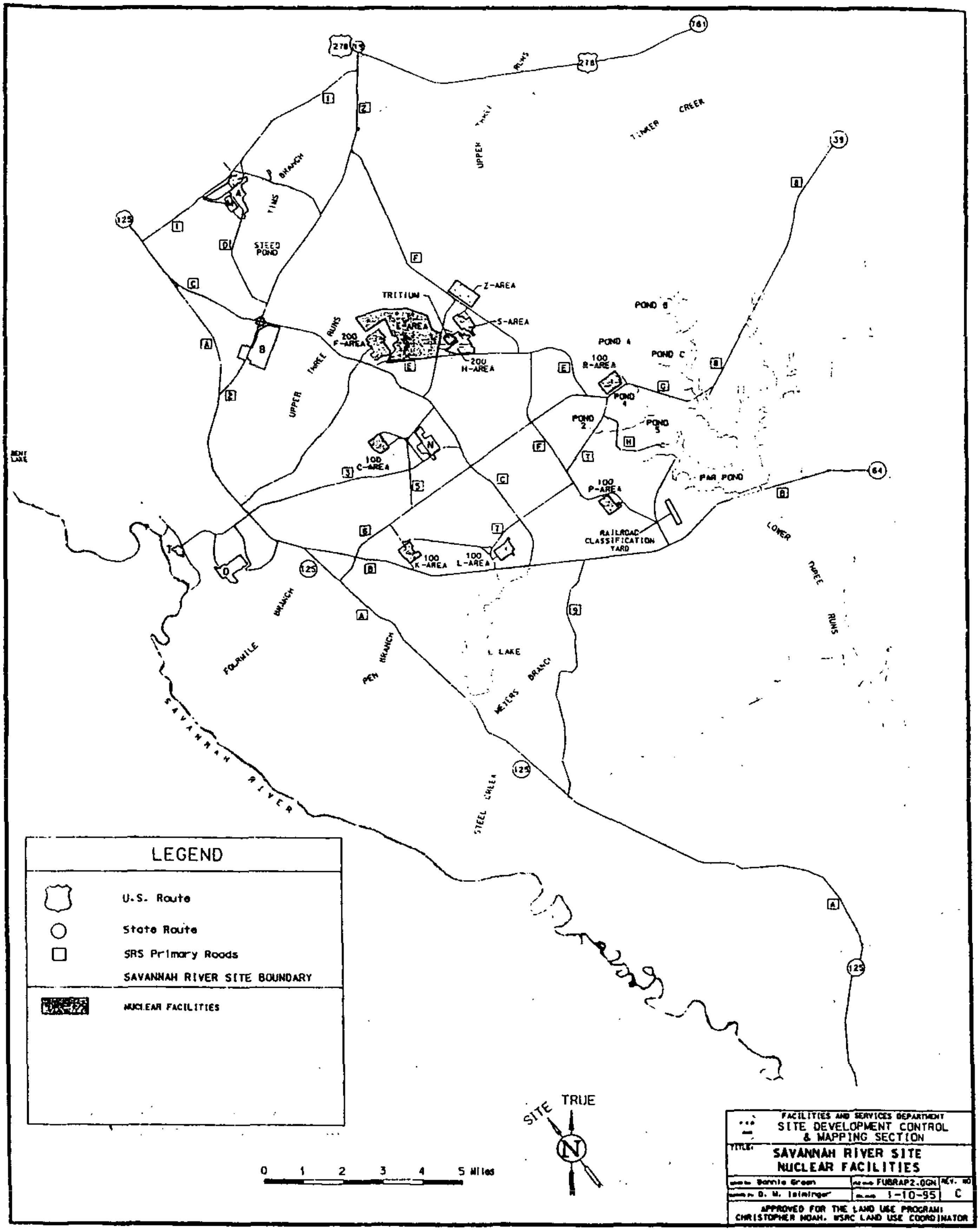
The tritium facilities, located in H Area, extracted tritium from irradiated targets and unloaded returned reservoirs, purified recycled tritium, and reloaded reservoirs. The tritium recycling mission, modified by anticipated program changes, will continue at SRS. Activities include recycling of weapon components for the active stockpile and extraction of tritium from remaining irradiated targets. In the long term, SRS will continue to recycle tritium and to add new nonnuclear missions.

Waste Management Facilities

High-level waste storage tanks are located in F Area and H Area. In S Area, the Defense Waste Processing Facility, which is undergoing startup testing, will immobilize the high-activity portion of this waste in glass. The Saltstone Facility, already in operation, solidifies the low-level fraction in grout (saltcrete) in Z Area. The Effluent Treatment Facility (ETF) for low-activity liquid wastes also is located in H Area.

Solid Waste Disposal Facility (SWDF)

The SWDF is a centrally located, 195-acre complex in G Area and E Area that stores and disposes of radioactive solid wastes. Facilities include the Low Level Radioactive Waste Disposal Facility, Transuranic Waste Storage Pads, and the Mixed Waste Storage Buildings.


LEGEND
U.S. Route
State Route
SRS Primary Roads
SAVANNAH RIVER SITE BOUNDARY
NUCLEAR FACILITIES
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Z-AREA
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200 F-AREA
200 H-AREA
100 R-AREA
100 C-AREA
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100 K-AREA
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RAILROAD CLASSIFICATION YARD
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APPROVED FOR THE LAND USE PROGRAM: CHRISTOPHER NOAH, WSRC LAND USE COORDINATOR

Utilities

Overview/Program Description

The Power Operations Department oversees facilities that provide electricity, steam, river cooling water, domestic water, service water, and sanitary waste treatment. Steam and electricity are produced in the coal-fired cogeneration plant, while steam only (for K Area) is supplied by the operation of three diesel fuel-fired boilers within the area. Reactor cooling water is pumped from the Savannah River through a system of underground pipes into the 186 basins located throughout the reactor areas. Power Operations controls the pumping rate and the basin level. Domestic and service water are supplied through a deep-well pump system within the site's areas, and sanitary waste is treated in 20 plans located throughout the site. Power Operations personnel monitor and sample all sanitary outfalls for National Pollutant Discharge Elimination System (NPDES) permit compliance. They also operate

- chilled water systems for air conditioning and process ventilation
- process cooling water systems and air compressors for instrument air service
- process air service
- plant air service
- the large exhaust fan facilities in the canyon areas

Purpose/Missions

Domestic Water

SRS has 28 domestic water systems that provide water for drinking, washing, showering, and lavatories. Twenty-seven water systems are supplied with treated groundwater from site production wells.

Earthen Dams

SRS has 13 structures that are considered dams by definition. Built of earthen materials, they were constructed to create cooling reservoirs and ash containment basins, or were original (pre-SRS) farm ponds. All the dams are located in D Area, G Area or H Area. The largest dam is at Par Pond, a 2,640-acre reservoir on Lower Three Runs Creek. The reservoir's purpose was to serve as a recirculating cooling basin for R Reactor and P Reactor, which no longer are operating.

The Earthen Dam Safety Program, established in 1990, is responsible for maintaining the structural integrity of the dams while minimizing environmental impacts.

Electricity

The SRS electric grid is a 115-kilovolt (kV) system in a ring arrangement that supplies power to operating areas, water pumping stations, administrative areas, and a number of independent and support function areas. Three commercial "tie lines" connect with the SRS grid. The 115-kV system includes about 100 miles of transmission lines. Power normally is supplied to the SRS grid by South Carolina Electric & Gas Company. Seven on-site, coal-fired turbogenerators supply a fraction of the on-site load and limited reserve power.

Sanitary Wastewater

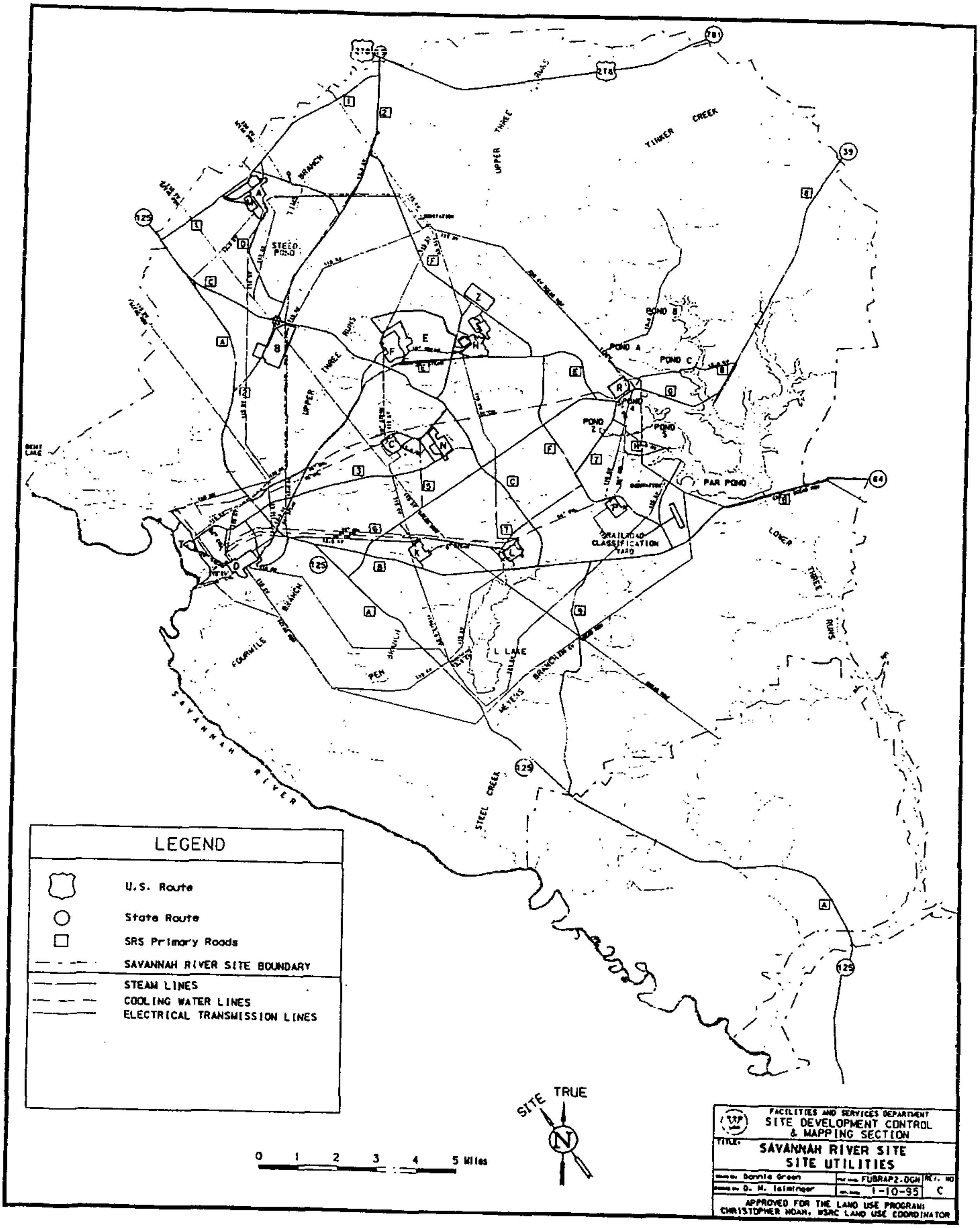
SRS has 20 operating package-type sanitary wastewater treatment plants in 13 site areas. Because of changing environmental compliance requirements, sitewide area population shifts, and existing plant optimum capacity limits, systems in the following areas are now considered inadequate: A, B, C, F, H, N, F, and S. The Central Sanitary Wastewater Treatment facility is currently under construction to replace these systems. Total design capacity is rated at 1.05 million gallons per day.

Steam

Building and process steam is provided to various areas across the site using the steam distribution system. The interarea steam distribution system consists of more than 20 miles of interarea steam piping, ranging in diameter from 6 inches to 24 inches. The D-Area Powerhouse is the primary source of process steam on site. Supplemental steam is produced by the H-Area powerhouse. Steam lines operate between other areas to provide an alternate source of steam in case of boiler failure and to provide a supplemental source between areas of peak demands.

River Water

The river water system provides cooling water for various process uses, primarily reactor operations, from the Savannah River and the Par Pond reservoir. This system consists of four pumping stations--three on the river and one on Par Pond. SRS has a network consisting of more than 50 miles of underground piping, ranging in diameter from 48 inches to 84 inches.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U.S. Route
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SRS Primary Roads
SAVANNAH RIVER SITE BOUNDARY
STEAM LINES
COOLING WATER LINES
ELECTRICAL TRANSMISSION LINES
SAVANNAH RIVER
PAR POND
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STEEL CREEK
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UPPER THREE RUNS
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Threatened/Endangered/Sensitive-Species Management

Overview/Program Description

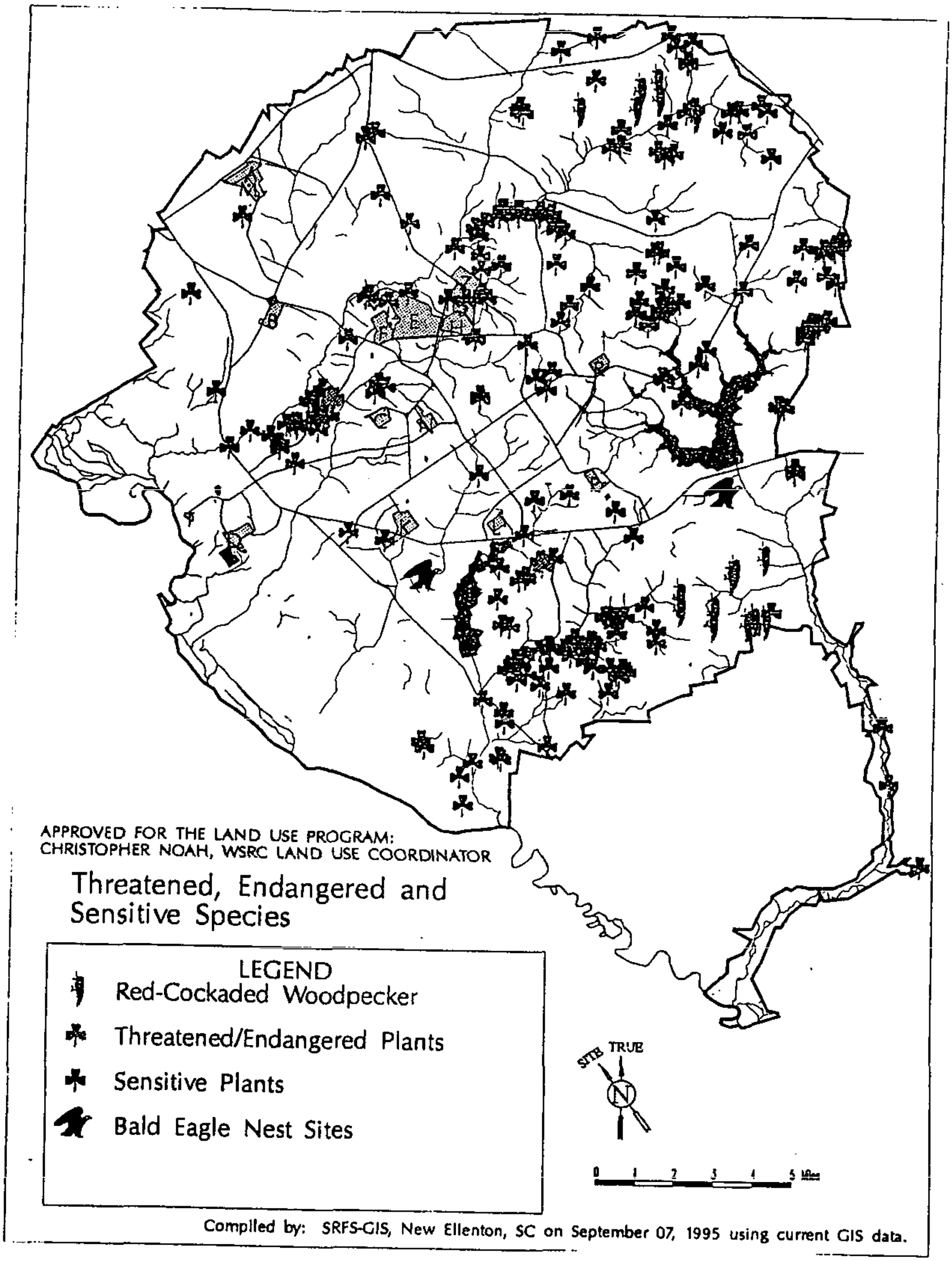
An endangered species is one that is in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered throughout all or a significant portion of its range within the foreseeable future. Sensitive species are simply those for which population viability, or continued existence, is a "concern."

The overall objective of the USFS wildlife, fisheries, and botany program at SRS is to attain and maintain viable populations of all plant and animal species native to the region to ensure the maintenance of biological diversity. The Endangered Species Act (ESA) requires a proactive approach to endangered- and threatened-species management on federally owned land. However, no minimum acreage is required by law. SRS works closely with the U.S. Fish and Wildlife Service (USF&WS) to determine the adequate habitat necessary to maintain threatened and endangered species. Endangered and threatened species are designated and administered by the USF&WS. The management of rare species, a vital part of the overall wildlife, fisheries, and botany program at SRS, is the responsibility of SRFS.

Purpose/Missions

SRS provides habitat for five endangered species. Several reside on the site year-round, while others are transient visitors. The number of red-cockaded woodpeckers has grown from four birds in 1985 to 77 birds in 1994, and the site supports two active breeding pairs of bald eagles. Also, the endangered wood stork forages on site, and the shortnose sturgeon, an anadromous fish, has been reported in the Savannah River adjacent to SRS. The American alligator, fairly abundant on the site, is listed as threatened (by virtue of similarity in appearance to the endangered crocodile). The smooth purple coneflower is an endangered plant found at two locations on the site.

SRS also is home to many sensitive species, including 28 plants, five birds, three reptiles, one fish, two mussels, three mammals, an amphibian, and an insect. These are species, without ESA protection, for which the population viability is of concern to the USFS. The purpose of identifying sensitive species is to ensure species viability and to prevent any trend toward endangerment that would result in the need for federal listing under the ESA.


APPROVED FOR THE LAND USE PROGRAM:
CHRISTOPHER NOAH, WSRC LAND USE COORDINATOR
Threatened, Endangered and Sensitive Species
LEGEND
Red-Cockaded Woodpecker
Threatened/Endangered Plants
Sensitive Plants
Bald Eagle Nest Sites
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Compiled by: SRFS-GIS, New Ellenton, SC on September 07, 1995 using current GIS data.

Recreation

Overview/Program Description

Trails

SRFS has constructed and maintains three walking trails at SRS to provide opportunities for employees to exercise during lunch breaks and nonworking hours. The Piney Woods Trail is on the north side of SRS Road 1, across from the 700-Area. The "S" Area Trail is on the north side of SRS Road F across from S Area complex. The third trail is located at the SRFS administrative site.

Boy Scout Camporee

SRFS supports SRS each year in hosting the annual Georgia-Carolina Boy Scout Council Fall Camporee, where about 500 Scouts work toward merit badges during a weekend of camping and other activities on the site.

Hunting/Fishing

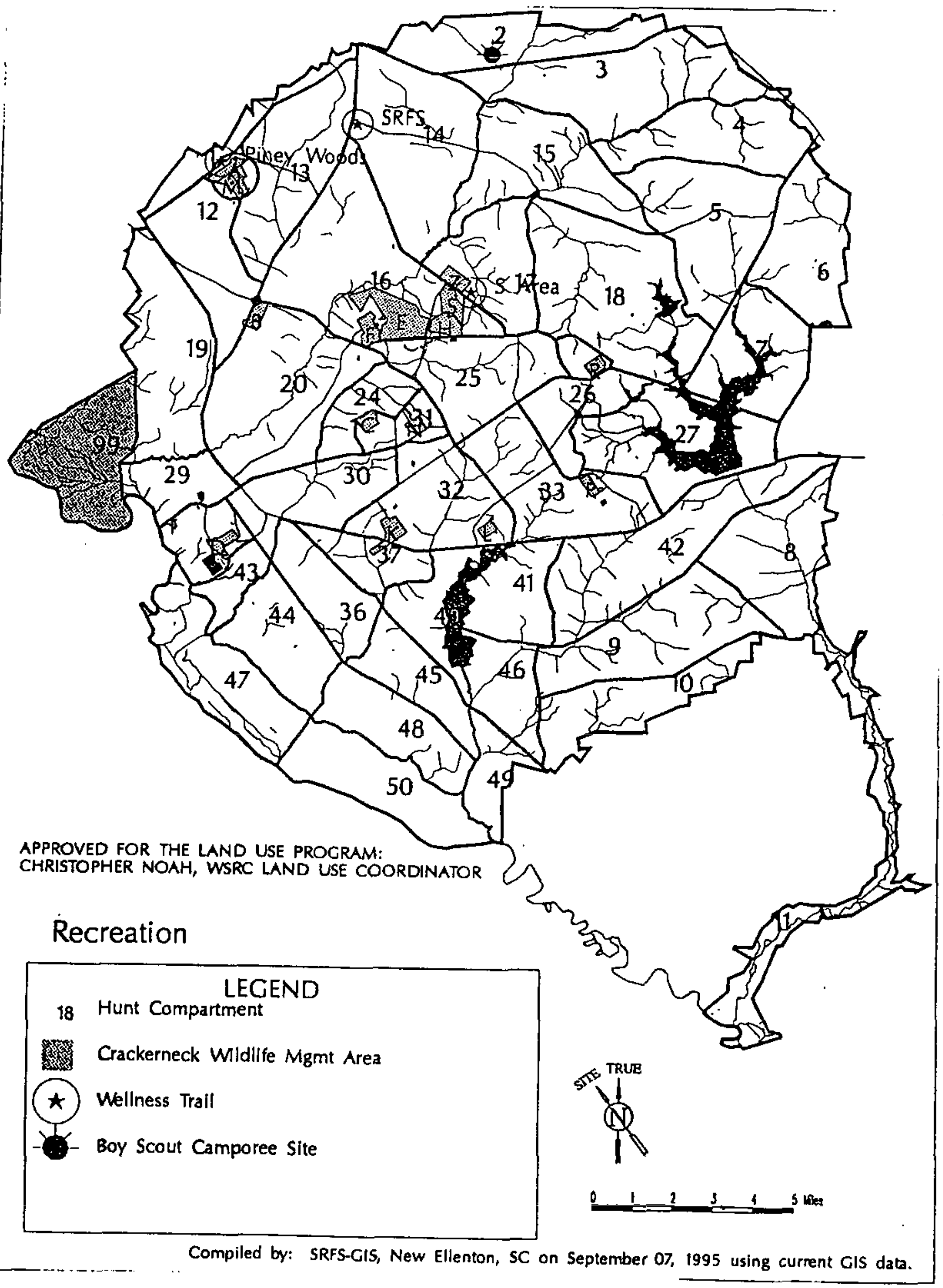
A portion of SRS is open to the public for hunting and fishing. Public hunts are allowed under DOE Order 4300.1C, which states that "all installations having suitable land and water areas will have programs for the harvesting of fish and wildlife by the public." The Crackerneck Wildlife Management Area is comprised of 4,780 acres of the site located adjacent to the Savannah River. This area is Sportsmen must obtain a permit to hunt or fish this area; however, there is no charge. cooperatively managed by SRFS and the South Carolina Department of Natural Resources. Opportunities exist to hunt waterfowl and big (deer, hogs, and turkeys) and small (quail, squirrels, and rabbits) game, and to catch a variety of fish.

Controlled Hunts

Hunting opportunities also are available on much of the rest of the site. SRFS is responsible for developing and coordinating a comprehensive deer control program--in close cooperation with WSRC, SREL, the South Carolina Department of Natural Resources, and Wackenhut Security, Inc. Recreation is not the primary purpose of these controlled hunts. The mission of this activity is to conduct harvests that will

- lower the incidence of animal-vehicle collisions on site
- produce a healthy deer population
- reduce the feral hog damage to valuable plant communities, reforestation efforts, and ecological research sites

There is a $50 fee to hunt, and hunters are chosen at random from a list of those who registered. Each animal harvested is monitored for contaminants, and harvest data such as age, sex, and weight are compiled.



2
3
SRFS
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Piney Woods
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S Area
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10
48
49
50
1
APPROVED FOR THE LAND USE PROGRAM:
CHRISTOPHER NOAH, WSRC LAND USE COORDINATOR
Recreation
LEGEND
18 Hunt Compartment
Crackerneck Wildlife Mgmt Area
Wellness Trail
Boy Scout Camporee Site
SITE TRUE
N
0 1 2 3 4 5 Miles
Compiled by: SRFS-GIS, New Ellenton, SC on September 07, 1995 using current GIS data.

RCRA/CERCLA Waste Units and Site Evaluations

Overview/Program Description

SRS manages waste materials regulated under Resource Conservation and Recovery Act (RCRA), a comprehensive law requiring stringent management of hazardous waste/constituents. The Hazardous and Solid Waste Amendments were passed in 1984 to further augment RCRA.

Regulated units are surface impoundments, landfills, and waste piles (collectively termed "land disposal units") that have received hazardous waste since November 19, 1980, and that require RCRA operating or post-closure permits. Nonregulated units, termed Solid Waste Management Units, may include any activity where hazardous constituents may remain uncontrolled and potentially released to the environment. Investigations and corrective actions at these units are mandated by RCRA Section 3004(u).

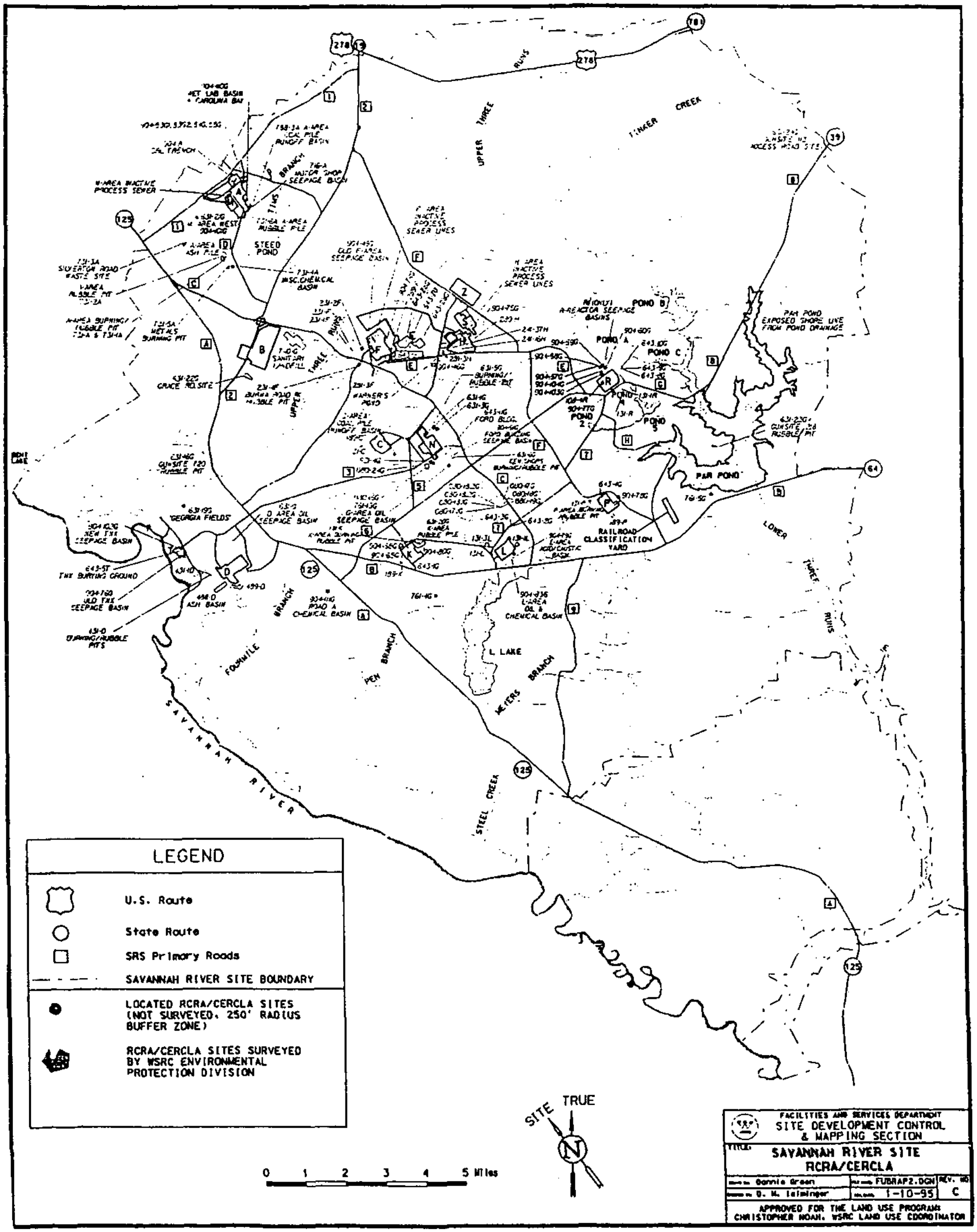
On December 21, 1989, SRS was placed on the National Priority List. A site included on the list falls under the jurisdiction of Comprehensive Environmental Response, Compensation, and Liabiability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986. These acts impose requirements for the remediation of hazardous substance releases and of inactive hazardous waste disposal sites. The National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300) was established under Section 105 of CERCLA. Its purpose is to provide the organizational structure and procedures required to prepare for and respond to discharges of oil and releases of hazardous substances, pollutants, and contaminants.

According to Section 120 of CERCLA, DOE has negotiated a Federal Facility Agreement (FFS) with EPA and SCDHEC to coordinate remedial activities at SRS into one comprehensive strategy that fulfills both RCRA 3004(u) and CERCLA investigation and remedial action requirements. Figure 6-26 shows the location of RCRA Facility Investigation/Remedial Investigation units listed in the FFA, which was executed January 15, 1993, with an effective date of August 16, 1993.

Purpose/Mission

The SRS Site Evaluation List, Appendix G, of the FFA, identifies areas that will require an initial evaluation to determine if remedial action is necessary. Approximately 300 such areas have been identified as potential waste units at SRS. Appendix C, the RCRA/CERCLA Units List, identifies waste units that will be subject to the integrated remedial investigation program specified in the FFA. Appendix H of the FFA lists the RCRA-regulated units subject to corrective action under the South Carolina-designated program.

SRS is in the process of coding waste sites according to the FFA schedule. The F-Area Burning/Rubble Pits, the D-Area Burning Rubble Pits, the Burma Road Rubble Pit, the Old F-Area Seepage Basin, the Silverton Road Waste Site, the M-Area West, and the L-Area Oil/Chemical Basin and Acid/Caustic Basin have an FFA fiscal year 1995 commitment for a "Corrective Measure Study/Feasibility Study Report."


LEGEND
U.S. Route
State Route
SRS Primary Roads
SAVANNAH RIVER SITE BOUNDARY
LOCATED RCRA/CERCLA SITES (NOT SURVEYED, 250' RADIUS BUFFER ZONE)
RCRA/CERCLA SITES SURVEYED BY WSRC ENVIRONMENTAL PROTECTION DIVISION
0 1 2 3 4 5 Miles
SITE
TRUE
N
FACILITIES AND SERVICES DEPARTMENT
SITE DEVELOPMENT CONTROL & MAPPING SECTION
SAVANNAH RIVER SITE
RCRA/CERCLA
FUBRAP2.DGN
1-10-95
C
APPROVED FOR THE LAND USE PROGRAM:
CHRISTOPHER NOAH, WSRC LAND USE COORDINATOR
278
19
781
39
125
64
SAVANNAH RIVER
PAR POND
L LAKE
STEED POND
POND B
POND C
UPPER THREE RUNS
TINKER CREEK
FOURMILE
PEN BRANCH
MEYERS BRANCH
STEEL CREEK
LOWER THREE RUNS
RAILROAD CLASSIFICATION YARD
GEORGIA FIELDS

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Appendix I Responsiveness Summary

Comments on Draft Future Use Project Report, Revision 0, October 1995, with SRS Responses

The following comments were received by Don Druelle, DOE-SR Future Use Project Leader. The comments are shown in italics and the responses are shown in plain text.

This is an excellent draft product. While I have not seen the missing enclosures, you and your team "caught" the feeling and concerns of all of the stakeholders. In addition you did an excellent job of compiling the information into a usable document.

Your document did bring us several new concerns that to date I have not heard mentioned:

a. *With all of the millions of tax dollars being spent to clean up SRS, I can not believe SRS would allow a new industry to come on site and further contaminate the ground or surface water.*

   While I would prefer to see only federal research or state college level (SREL) education at SRS, the decision may be made to allow public or corporate industry to locate on SRS.

   My concern is the inability of Westinghouse or DOE to monitor and then control any contamination caused by this new industry. Then the question of whose contamination it is, was it there before the industry dumped its waste on the ground. Who will pay to clean it up. Then the law suits. Private land is worthless once contaminated. Best to contaminate federal property if you are a business. For that reason, this document needs to state only "environmentally safe" private or corporate clean industries will be permitted to lease land. industry that poses no threat to the environment.

   This does not even get into the question of "favoring" one business over another. Once you allow one "of a kind" how are you to stop "another" of the same kind.

   My recommendation is to not allow any that are not completely "environmentally clean." Then you have less of a problem.

Response 1. Any new industry that is allowed on SRS property will be required to seek appropriate environmental permits from the State of South Carolina and the Environmental Protection Agency. In addition, the lease agreement will require the industry to close the site in an environmentally protective manner and will also require any post-closure monitoring. A financial disclosure statement will also be required to assure that a private industry will have the finances to perform any remediations activities, if needed. The Department will remain responsible for any pre-existing conditions.

b. *Page 7, Para. 2.1.1 (5) Commercial industrialization of industry zones needs to have an additional "bullet" added.*

I remember at one of the meetings adding this "bullet." It was probable one that the minutes have not yet been included.

Small critical ecology areas may be identified in an Industrial Zone. These sites need to be identified and protected with easements and buffer zones.

Response 2. The bullet is correct as shown. Although there was discussion about the ecological zones, the final recommendation did not include this "bullet". However, this is included in the discussion in the Vision document. Please see *Appendix B, Citizens Advisory Board Vision Document.*

Please emphasize DOE shall vigorously pursue commercial industrialization of approximately 1/3 of site land area. I would like to see them issue a Request for Proposal to a real developer.

Response 3. While we agree that we should allow commercial industrialization on SRS property, we have not completely industrialized the 10% of the land currently "zoned" as industrial. We would prefer to use existing industrial areas for future industrial uses before we consider using previously undeveloped land.

The Savannah River Site (SRS) Future Use Project has yet to develop a credible strategy for incorporating land use planning into decision-making. The analysis and conclusions offered in the draft report were not developed through an effective public participation process. In addition, the draft report does not reflect a well developed, implementable plan. The findings of the report would be better presented as the early, and inconclusive, results of a process which must continue if a quality product is to be produced.

Response 4. The *SRS Future Use Project Report* was not intended to be a planning nor a decision-making document. The objective of the report was to determine interested stakeholders' future use options. Planning activities and resulting documentation are done through an independent process. The data provided in the this report will be analyzed and considered in future long-term planning and decision-making activities. Although the final report does not reflect a consensus recommendation, all comments gathered during the project were shared in full with the Citizens Advisory Board, which does have federal advisory committee status and provided specific recommendations. The recommendations in this report parallel and, in all but three instances, duplicate the consensus recommendations of the Citizens Advisory Board.

Below are several of our specific concerns related to the draft report. Since we believe the report needs substantial revision, we request that a revised draft be issued for additional comment before the report is finalized.

Process. The draft report fails to adequately discuss the process by which public input was solicited. Instead it presents too strong an image of agreement and conclusiveness, even referring to the results as "stakeholder-preferred options."

In fact, though, the public participation process was unnecessarily divisive and did not include the kind of meaningful dialogue or substantive discussions necessary to evaluate the merits of various options, let alone truly arrive at a list of alternatives preferred by the public.

Response 5. The input process is now explicitly described and the lack of consensus explained. We believe that, because the majority of comments fit into a number of specific themes and because these themes so closely match the consensus-driven CAB recommendations, these can truly meet the definition of "recommendations." Furthermore, comments and preferences that did not fit particular themes are also included.

There was often poor cooperation between the Department of Energy (DOE) and the SRS Citizens Advisory Board (CAB) Risk Management and Future Use Subcommittee. For example, DOE frequently changed its plans for working with the Subcommittee. At the beginning of the process, DOE approached the Subcommittee about jointly sponsoring the first meeting, then reneged on the offer and almost made no mention of the CAB's role during the meeting. Similar actions continued throughout the process, and while better cooperation was eventually established, the degree varied considerably from meeting to meeting.

Response 6. Admittedly there were difficulties in defining the roles the Future Use Project Team and the Citizens Advisory Board subcommittee. The example cited above is typical of the unintended results of letting the public define the meeting agenda and was not meant to diminish the role of the subcommittee. We believe the final product proves how mutually supportive that process was.

Additionally, the nature of DOE's public meetings allowed little opportunity for detailed discussion of the merits of various comments, including the potential implications of acting upon them. Instead the meetings were more designed to simply record whatever thoughts were offered. Consequently, there was no meaningful effort to understand differences among various opinions or to arrive at agreement among the parties participating. There was also inadequate opportunity for participants to openly develop their ideas into a workable plan.

The final report should describe public input received to date as a foundation on which future discussions could be based to perhaps eventually arrive at a better, more representative plan. It should also propose a plan to bring concerned citizens together in a meaningful dialogue to develop a workable method for better considering land use planning in decision making at SRS.

Response 7. At our first public meeting, we were asked to accept all comments as meritorious and to include each in our report. Further, many participants asked the Department to develop strawman options and a public participation plan for their consideration and approval. The public participation plan, focusing on both DOE and CAB, was approved by the involved stakeholders, and the strawman options provided a starting point for discussions and brainstorming. Please see Response 4.

"Stakeholder Preferences". The failure of the process is apparent when analyzing the details of the report. This is simply not an adequate plan on which to base the many important decisions which could ultimately be impacted by land use. Several of our more significant concerns in this regard are described below.

The first so-called stakeholder-preference is that, "SRS boundaries should remain unchanged, and the land should remain under the ownership of the federal government." (p.1) The text *acknowledges public disagreement with this preference, highlighting the fact that the process did not reach definitive conclusions.*

Please see Response 4.

Additionally, the rationale offered for maintaining the land intact is an insufficient basis for decision making. For example, keeping boundaries intact for "security and safety concerns" does not reflect consideration of actual site conditions which don't necessarily require the existing boundaries for maintenance of security and protection of the public. It also doesn't reflect changes which might occur over time as conditions and local needs evolve. The other principal rationale offered for keeping the current site boundaries is the view of SRS as a national asset for "future national needs" and a location for environmental research. Again, this may support long-term federal control of some portion of the land but not necessarily all of it.

Response 8. The majority of stakeholder comments on this theme did not qualify or define specific future needs, merely the fact that the current activities, including environmental research and future national security efforts could benefit from an intact SRS.

The second so-called stakeholder-preference is that, "Residential uses of SRS land should be prohibited." Public comments recorded in the document, though, show that some citizens suggested limiting - not prohibiting - residential development. (p. A-3) This is an important distinction because it demonstrates that some citizens recognize the differences in risk associated with various parts of SRS and that pressures to residentially develop some portion of SRS may emerge. Consequently, decision makers would do better to keep the potential for residential use in mind than to assume that it will be prohibited.

Response 9. We agree that a few individuals desired limited residential use. However, it was clearly evident that the majority of stakeholders did not want residential uses.

The fifth so-called stakeholder-preference is that, "All SRS land should be available for multiple use (e.g., ecological research, natural resource management, research and technology demonstration, and recreation)." (p. 2) The explanatory text, though, only indicates that many citizens expressed an interest in "continuing, if not expanding" current multiple use practices. This is an important difference since maintaining some land areas for exclusive uses (e.g., ecological research set asides, security zones) might be important.

Response 10. Under the National Environmental Research Park (NERP) concept, multiple use of SRS land can continue by allowing ecological research, natural resource management, research and technology demonstration, and recreation. However, the appropriateness of any combination of uses would be determined in specific planning documents.

The SRS Future Use Project has introduced many ideas of land use planning to communities around SRS and begun cataloging public concerns and opinions. Building upon this foundation to obtain agreement among diverse interests and create a credible, implementable future use plan will require considerably more work. As this work continues, it is important for DOE to remember that regulatory and other key decisions which might consider land use should be based on a well *reasoned plan that is consistent with the Department's many responsibilities, not merely on the stated wishes of any particular group(s).*

Response 11. We agree that planning and decision-making activities will require continued public input which will require a review and update of the stakeholder-preferred future use options described in this report at some point in the future.

I have received the package on the potential future projects here at SRS. I was disturbed by some of the comments that people made, but one thing I am sure of is there is alot of fear and ignorance about the site. Growing up in New Ellenton, I was in the company of people who worked at SRS and I, too, new nothing about the SRS because of the code of silence. Now that the media has examined and cross-examined the site, you would think people would wise up. There is so much mistrust about the government. I praise the job you and your staff are doing. I've been employed on the site now for 13 years, and things have changed. I remember well the code of silence.

I've been an avid hunter all my life so you know where this letter is going. If you were a hunter, you would understand why I'm pushing for this land to come under the SCDNR. Private land owners are going to where the money is, and that is leasing their land to out-of-state stakeholders such as Florida and North Carolina. Did you know that land per acre is paying $30.00 for hunting rights. Where does this have the middle class and lower class? There is nowhere to hunt because currently the land is being over crowded. I would like to thank DOE for expanding Crackerneck. There was an accident waiting to happen if they hadn't, due to overcrowding. I would like to see the area west of 125 opened up to SCDNR and other areas as well for hunting and recreation but not for industry other than DOE, and the boundaries should be tightened. Sandia Labs and Lawrence Livermore don't take up that much space. Let's protect the environment and protect endangered species. I would like my children to be able to walk the woods of SRS with their children and explore the beauty and receive the bounty of this beautiful place that I've grown up on and worked on. I don't think I have to make you knowledgeable of the fact that hunting and fishing in South Carolina are their largest money makers in our state.

Response 12. As you know, there is limited hunting allowed on SRS property now, and we have given some additional land to South Carolina Department of Natural Resources on a trial basis for one year. After one year, we will evaluate this decision. About your comment on additional land available for recreational use, we will continue to look at each proposal on a case-by-case basis; for example, Boy Scouts have used portions of SRS lands for the last few years for their Camporee, and now Girl Scouts are using parts of SRS land for their activities.

Appendix B Citizens Advisory Board Recommendations (page B-1) of the subject report states that the RMFUS' "vision" document will be included in this appendix in the final report if completed in time.

This timeframe for inclusion of the Subcommittee's workproduct which reflects its consensus-building efforts and gives justification for, support of, and the reasoning behind the CAB Recommendations is not known to me. However, knowing the amount of time and effort put forth by all parties, I cannot believe the SRS Future Use Project Team would publish the final project report without such "vision" document.

Response 13. We agree that the Vision document should be included in the report and were glad that the SRS Citizens Advisory Board voted on the final version in time for this report. See Appendix B for the final Vision document, as voted on by the SRS Citizens Advisory Board on January 23, 1996.

Thank you for the opportunity to comment on the October Draft of SRS Future Use Project Report. I find the draft to be inadequate and almost shows an abdication of DOE-SR responsibility for SRS future use of ESR lands to DOE-HQ. I recommend strongly that this report be rewritten and reissued for comments before it is sent to DOE-HQ. I have reached these strong conclusions from the following:

- *Having been involved in this activity for the last 1 to 1-1/4 years, the report doesn't seem to display any process for reaching consensus among the stakeholders nor no DOE-SR views on the future use of SRS lands.*

Response 14. Because some of our stakeholders wanted to use the SRS Citizens Advisory Board and others wanted to provide input directly to DOE on their preferences, we did not design the process to reach consensus. However, the report recommendations do reflect the majority of opinions we received during the process.

In addition, we have included the DOE-SR views of future use of SRS lands. See *Section 2.1.4, Savannah River Operations Office Recommendations.*

- *I participated in most of the public meetings and they were all meetings (as listed in Section 1.3.2) to listen to the public's views on future use of these lands. This resulted in a diverse set of comments identified in Appendix A but no attempt, at those meetings, to reach consensus and I see none in the report except into the very general categories discussed.*

Response 15. You are correct. See Response 4.

- *The SRS Citizens Advisory Board went through a more complete process of obtaining stakeholder input (from a smaller population consisting of those attending the CAB subcommittee on Risk Management and Future use and the CAB itself) and reaching consensus on a vision for SRS Future Use. As a result, the CAB made a nine part recommendation to DOE several months ago (listed in your report as Appendix B). Six of the nine part recommendation show up as themes in the Executive Summary and Section 1.2 of your draft report. The following parts were omitted:*
    - *Research and technology demonstration (Part 6 of the CAB recommendation)*
    - *Natural resource management striving for biodiversity (Part 7 of the CAB recommendation)*
    - *Increased recreational opportunities (Part 8 of the CAB recommendation).*

The reason for omitting these three parts, which are in good agreement with many of the comments received at the public meetings, as themes is not clear to this reviewer. They should be included. (The CAB consensus was by far the most complete effort described in this report.)

Response 16. We have revised the report to more closely follow the recommendations of the SRS Citizens Advisory Board. Our intent in the first draft of this report was to include the CAB's recommendation, but due to editing, the meaning was lost.

- *Section 2.1.2 is given equal weight to the CAB recommendation in Section 2.1.1 suggesting that the Citizens for Environmental Justice went through a similar process. The report is silent on what the group did and the level of consideration provided by that group. Appendix C doesn't indicate that the Citizens for Environmental Justice reached consensus. How were the views expressed in Section 2.1.2 reached? The consensus does not seem to represent the individual views.*

Response 17. The Citizens for Environmental Justice did not provide us with the details on the process they used for their recommendations on future use. However, we do know that they held a one-day workshop on future use in Savannah and presume that the recommendations were provided as a result of that workshop.

- *The Site Land Use Technical Committee information should be made available for review. The conclusions of these "23 senior technical experts" represent a significant and important group of stakeholders.*

Response 18. We agree. We have included their recommendations in the final report.

- *I conclude that no other group provided recommendations by the absence of information in Appendix G.*

Response 19. You are correct. No other group has provided recommendations to DOE-SR.

- *Appendix F identifies the Future Use Project Team and Section 1.3.2 infers this group briefed a number of clubs and organizations (listed in Appendix G) but I could find no input from these organizations. It sounds like these groups said "nice presentation and thank you for coming" but gave no input. That seems incredible to me; the input obtained should be included.*

Response 20. Of the groups listed, only the SRS Citizens Advisory Board, SRS Land Use Technical Committee, and Citizens for Environmental Justice chose to provide DOE-SR with recommendations on future use.

- *A section should be added on stakeholder participation resulting from mail-outs provided for this project. I am sure you received comments from these extensive mailings. This section should also include the level of effort your staff has expended obtaining these comments (both in mail-outs and responses received). SRS should benefit from attempts to get comments even though, in some cases, comments were not received. Those receiving the mailings were given the opportunity to respond. (You can lead a horse to water but you cannot make him drink.)*

Response 21. We agree and have added Section 2.5 to the report to include what we heard from public meetings and mailings.

- *The report contains no information on individual participation in the process. The number of individuals, the type of stakeholders (internal and external) and location are needed. This would help readers of the report understand the level of stakeholder input and the regional diversity of the comments.*

Response 22. It would be difficult to provide the statistics you requested because people from various parts of South Carolina attended public meetings outside their "home" area. For example, at the meeting in Beaufort, the most of the people who attended were from North Augusta and Aiken, South Carolina.

- *The report lacks clarity. I did not provide these specific comments since I expect my major comments to be incorporated and the document reissued. If you desire specific comments, have someone call me.*

Response 23. Thank you for your suggestions. We did talk to you on January 17, 1996, and you provided some additional comments which we believe have made the report better. Thank you.

Per your invitation for public comments regarding the future use of the Savannah River Site, those participants at the November 4-6 meeting of the From Trident To Life Campaign, a Southeast Regional campaign to redirect resources from military spending toward the meeting of human needs, meeting in Columbus, Georgia, wish to transmit to you the following comments:

- *All nuclear production should be halted.*

- *No tritium production facility should be constructed.*

Response 24. We are no longer producing plutonium and tritium due to the end of the Cold War; however, the Department must maintain this capability and retains the mission of recycling tritium in the active weapons stockpile. A Record of Decision on the Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling was issued on December 6, 1995. It recommended an accelerator or a commercial reactor as the new tritium supply technology with SRS being the preferred site for an accelerator.

- *There should be no residential development (except that one wag, to general approbation, suggested the possible exception of a retirement community for former DOE and Westinghouse management).*

Response 25. No residential use is one of the recommendations made in this report.

- *Nuclear materials from other countries should not be stored at SRS.*

Response 26. The only nuclear materials being considered for storage at SRS are spent nuclear fuel that the United States lent to other countries for their universities to study, and various National Environmental Policy Act documents have been prepared and additional documents are being prepared to address this issue. The Record of Decision for the *Environmental Assessment for Urgent Relief Acceptance of Foreign Research Reactor Spent Nuclear Fuel* determined that there would be minimal, if any, increased environmental effects from temporarily storing spent nuclear fuel at SRS. In addition, another document called the *Proposed Policy for the Acceptance* *of U. S. Origin Foreign Research Reactor Spent Nuclear Fuel Programmatic Environmental Impact Statement* is currently being prepared and is expected to be released in January 1996 with a Record of Decision projected for February. This Environmental Impact Statement will address spent nuclear fuel from other countries.

- *The only appropriate industrial activity would be the development and use of cleanup and containment technologies for nuclear and hazardous wastes.*

Response 27. We agree that development of cleanup and containment technologies for nuclear and hazardous wastes are industrial activities that should take place on SRS property; however, with over 310 square miles, we also believe there are other possible uses for the land. See the recommendations from the stakeholders in the Executive Summary and *Section 1.2, Stakeholder Recommendations for Future Uses.*

- *Savannah River Site should begin consultation with the Nuclear Guardianship Project in order to develop a very long-term method of safeguarding the mess there.*

Response 28. DOE welcomes public input in all of its planning and decision making.

- *We are opposed to privatization of the Site.*

Response 29. While we considered your comment, most stakeholders disagreed and expressed an interest in additional industrialization on the site. This report reflects all recommendations provided to DOE in summary form, including no private industry on the site. However, current Congressional guidance and Executive Branch policy is to save tax dollars through privatization, where appropriate.

Thank you very much for your consideration of our wishes.

On behalf of the From Trident To Life Campaign, I am yours for a Nuclear-free Future.

The draft report does a good job of capturing the common land use themes but not the future use themes. My interpretation of future use includes these and there were certainly many future uses suggested; active pursuit of these was recommended. "Having land available for many uses" is necessary but not sufficient. For instance, the government missions section only discusses the current activities but not future possible ones such as tritium production, HEU stabilization and temporary storage, plutonium pit manufacture, etc.

Response 30. We have modified the explanation of industrial uses at SRS to incorporate your comment.

The request for this report came from DOE-HQ and I consider DOE-SR also a local stakeholder. What does DOE-SR recommend? It seems to me that DOE-SR should synthesize the input from the local internal contractors and the local external public stakeholders, add the DOE-SR input and come up with a set of recommendations to DOE-HQ. The report suffers from the lack of recommendations to DOE-HQ.

<u>Response 31.</u> We have included the DOE-SR views of future use of SRS lands. See *Section 2.1.4, Savannah River Operations Office Recommendations.* DOE-HQ has not provided any recommendations as they want to know what internal and external stakeholders recommended. A summary report of all DOE sites recommendations is currently being prepared and should be available in March 1996.

A future land use map should also be included from DOE-SR and the internal stakeholders. Except for public stakeholders and the Citizens Advisory Board (CAB) recommendation 8, the only indication for land use zoning is reference to multiple use including industrial. In my view, that will not be sufficient with the regulators (EPA and DHEC) to allow industrial clean up standards to be used for actions on SRS. I also do not believe that they would allow industrial standards to be used for the whole 300 square miles. I believe that they are receptive to considering such standards for parts of the site where clearly they are appropriate - only if DOE formally makes a land use commitment. Such a commitment by DOE is cheap to do and will save millions of taxpayer dollars. A land use map is included as part of the CAB recommendation 8 but there is no reaction to it by DOE-SR. I believe that the CAB is expecting DOE-SR reaction to all nine parts of recommendation 8. I expect that is also true of the rest of the stakeholders. Hence, it is important for DOE-SR to give their response in the form of recommendation to DOE-HQ. This report is the place to do it.

<u>Response 32.</u> The second draft and final report of the Future Use Project included a map provided by DOE-SR as well as a recommendation. This map is the preferred map as it does not allocate as much land for industrialization as the SRS CAB-recommended map. We are not using all the currently "zoned" industrial areas now which are only 10% of the site land. We would prefer to use currently industrial areas before using previously undeveloped land.

Many will only read the Executive Summary. The current draft discusses the groups giving input but no mention is made of the internal stakeholders and their report. I hope that by your listing of external stakeholder groups that you did not mean to imply that you gave more weight to input from the CFEJ than the CAB; it wasn't even alphabetical.

In conclusion, the draft report does a good job of explaining what was done and what input was received. It needs to be strengthened by inclusion of DOE-SR recommendations to DOE-HQ including a land use map.

<u>Response 33.</u> All stakeholders comments and recommendations were considered in developing the recommendations. DOE-SR's recommendation can be found in *Section 2.1.4, Savannah River Operations Office Recommendations.*

Last week I received a copy of Revision 0 of the Future Use Project Report and appreciate you including me on your mailing list. The report seemed to be fairly complete and detailed as I remember the meeting I attended in Beaufort, SC. The concerns of the former landowners were well documented in several places in the report.

Since talking to you at the Beaufort meeting, I have received a letter from Mr. Donald Pearman of the Department of Energy through Senator Thurmond's office basically explaining that even though my "views" will be considered, any property determined to be excess will be disposed of *by the General Services Administration through official actions required by the Federal Property and Administrative Service Act of 1949 "offering it for sale to the general public on a competitive basis."*

Response 34. Because we recognize the close ties that many former landowners have to the SRS lands, we have modified the third recommendation to read: "If DOE or the federal government should ever decide to sell any of the SRS land, then DOE shall seek legislation to permit former landowners (as of 1950-52) and/or their descendants to have the first option to buy back the land they once owned."

So, since the interests' of the former landowners is a moot question, I have only one more comment (or request of DOE). At the Beaufort meeting, I pointed out that steps I understand were taken by DOE at Los Alamos, New Mexico, and Hanford, Washington, to document those areas by providing museum displays, etc. At that meeting Mr. Rick Ford, I believe of the Aiken DOE public relations office, told me unofficially that he thought surely some monies could be made available to museum the artifacts and other historical memorabilia available to document the area and towns before the coming of the plant to SC.

My request is for you to follow up this possibility with Mr. Ford and others to at least see a museum become a reality. The USC Architecture Department does not have a strong interest in this as a project. Mr. Hamer of the SC State Museum in Columbia and I would welcome working with you if such a project could be funded. Let me know if I may assist you in this area.

Response 35. While, in these times of tightening of federal budgets, it is difficult to find the funding for such projects, we and a number of external stakeholders are pursuing the idea of a visitors center for SRS and welcome your participation. Any description of site history would include the sacrifices former landowners made, as you have described.

Thank you for allowing my input as minimal as it may be.

Comments on Draft Future Use Project Report, Revision 1, January 1996, with SRS Responses

Thank you for the opportunity to comment on the new (January 1996) Draft of "SRS Future Use Project Report". I find the draft to be much improved over the October 1995 draft. Thank you for incorporating many of my suggested corrections. Our telephone conversation on your intent for the document helped clear up some of the points I have on this January report.

I would like to make the following comments on Revision 1. They are:

- *The report identifies themes and says (on P.i) they are called recommendations. Please add a sentence or two saying how these themes became recommendations and who's recommendations they are (DOE-SR, the Future Use Project Team or who). I support these being called recommendations; it adds strength to the document. Revise the report title to include recommendations. For example, "Stakeholder-Preferred Options for SRS Land and Facilities and __________ (who's) Recommendations for SRS Land Use".*

Response 36. We have changed the title of this report to *Savannah River Site Future Use Project Report, Stakeholder-Preferred Recommendations for SRS Land and Facilities.*

- *According to our phone conversation, Section 1 is intended to represent the Future Use Project Team's conclusion. To give balance I believe that the section needs a paragraph on the Team's conclusions from the comments received from those attending the public meetings.*

Response 37. We have added Section 2.5 to include the comments DOE-SR heard from public meetings and mailings. Section 1 is a brief summary of all comments and Section 2 is more details of recommendations from various groups and individuals.

- *As we discussed, Section 2 is a summary made by the Future Use Project Team of the major groups comments. The section provides a summary of the CAB Subcommittee, the Environmental Justice, the SRS LUTC, and the SRO recommendations. It omits the summary of comments from the public meetings, the letters and telephone comments received. Please include a summary of this input in Section 2.*

Response 38. We have added Section 2.5 to include comments from public meetings, mailings, and telephone calls.

- *Recommendation five on page 13 and on page D-4 uses the word "crated" which I expect should be "created". Please correct it in Section 2 (I don't feel correction is necessary in the Appendix since it is a quote of the report received.)*

Response 39. This was a typographical mistake in both places which has been corrected.

- *That same recommendation quotes a member of the Water Branch of Georgia's Environmental Protection Branch. It may be a correct quote but the facts do not sound credible. Please have someone verify that they are correct. If found to be incorrect, do not use the quote in Section 2.*

Response 40. This is a correct quote.

- *In several places, Section 2 uses the same words as used in the LUTC letter. This section is a summary prepared by the Future Use Project Team and should be carefully worded to ensure it is correct. For example in the middle of page 14 the sentence says "While important for future-use planning, the establishment of use and activity zones was not considered in the report." The statement is correct for the LUTC report and in Appendix D but is not correct in Section 2 since the CAB referenced material does not use this term. (see Section 2.1.1.)*

Response 41. This has been corrected.

- *I question the benefit of having two figures in Section 2. If both figures are retained, explain the differences and their significance.*

Response 42. There are two maps included in the report, one was the map recommended by the SRS Citizens Advisory Board and one recommended by DOE-SR. We have added wording in each section explaining the maps.

- *Add references to the CAB Recommendation 8 and the CAB backup document in Section 3. Also add the reference to the Citizens for Environmental Justice input.*

Response 43. We have added the references you suggested as well as adding the Land Use Technical Committee as a reference.

- *As we discussed by phone, Appendix A is suppose to represent all stakeholders' comments. Since the land use category "Cultural and Archaeological" section says no comments were received in this land use and pages C-1 discusses cemeteries and grave-yards and D-4 and D-12 have recommendation 6 on cultural resources, I must question the completeness of Appendix A. Please have Appendix A checked for completeness and modify as needed.*

Response 44. We have checked the Appendix A for completeness and have modified as you have suggested.

- *Since Appendices B, C, and D are reproductions of reports received on Future Use, I propose a lead in paragraph telling the reader that the following materials is a verbatim copy of the group's document. I think the source reference should be added in the paragraph. I further suggest reducing the print size and slightly indenting the quoted material so it is obviously a quoted source.*

Response 45. We have added a paragraph to each appendix as you suggested. We have also changed the body of the report to two columns to differentiate it from the appendices.

- *A section should be added to the report on stakeholder participation from mailings on this project. I am sure you received comments from these extensive mailings. This section should also include the level of effort your staff has expended obtaining these comments (both in mail-outs and responses received).*

Response 46. We have added Section 2.5 for the comments received from public meetings, mailings, and phone comments.

- *The report contains no information on the number of individuals participating in the process. The type of stakeholders (internal and external) and locations are needed. This would help readers of the report understand the level of stakeholder input and the regional diversity of these comments.*

Response 47. We have the total number of people who participated in the public meetings, but because many local residents added meetings in other regions, this information does not necessarily reflect accurate geographic diversity.

I have received a copy of Revision 1 of the Future Use Project Report. I think the thoughts of former residents of the area have been heard in that there are as many as nine references to former area residents or descendants. Also, my comments to the Revision 0 in November to you, I mentioned my desire for funding of a museum to preserve the heritage of the area. These comments have also been referenced in Revision 1.

My only concern now is that I do hope DOE will go forward with this idea of a museum. Surely if DOE can absorb "as much as $1 million" mistakes due to the installation of wrong flanges by Bechtel Savannah River Company, $50-100,000 could be found for an educational purpose. Please help by pursuing this project.

Response 48. While, in these times of tightening of federal budgets, it is difficult to find the funding for such projects, we and a number of external stakeholders are pursuing the idea of a visitors center for SRS and welcome your participation.

We have seen a copy of the latest draft of the SRS Future Use Project Report. We are concerned about its conclusions on the relationship between land use and protection of human health. We certainly object to the reference to "stakeholder-preferred options" and "stakeholder recommendations." As "stakeholders" ourselves, we do not consider that there has been proper analysis of the comments you have received, and we certainly have not noted any consensus-building efforts on DOE's part.

See Response 4.

You recommend that residential uses of SRS land should be prohibited and immediately thereafter say that DOE will seek legislation to assure that former owners have the first option to buy back what was once their land. For what purpose? To provide a vantage point to enjoy a desolate nuclear dump area?

Response 49. As the report states individual purchase is not currently possible, but would be pursued if conditions changed.

We are very much concerned about the current push to "privatize" many of the functions of SRS, and to move them off-site. The current plan to move the plant laundry operation off-site and turn it over to a private firm already cited for misbehavior at other sites, is a case in point. In the beginning, Aiken County turned over a huge area for SRS use. Evidently the present plan is to sprinkle the remaining county territory, particularly the north end of the county, with transplanted, privatized operations from the plant reservation.

The infrastructure to support such operations exists only in the plant reservation—it would have to be provided at taxpayer expense off-site.

We would become famous as "Aiken County—the county that glows in the dark"! We desperately need to diversify local industry, to protect our economic future. But if you carry out this off-plant privatization scheme, what chance would we ever have on attracting, say, something like the Volvo plant? And do you understand the property value damage that is done to communities out in the county when you move such projects in among them?

DOE and SRS are beginning to be considered bad neighbors in Aiken County.

See Response 29.

Please include the Land-Use Baseline Report as one of the appendices.

Response 50. Due to the costs involved in copying numerous color maps, we have included parts of the Land-Use Baseline Report. See Appendix H, *Relevant Maps From the SRS Land-Use Baseline Report.*

Please do not use words like "minority" and "disadvantaged"; instead use words like "people of color", "economically disadvantaged", or "disenfranchised."

Response 51. We have changed the wording as you have suggested.

The Executive Summary needs a vision statement, similar to the one in the Citizens Advisory Board Vision *document.*

Response 52. We have added a vision statement, as you have suggested.

The SRS Land-Use Baseline Report is a valuable document and should be included as an appendix in the SRS Future Use Project Report.

Response 53. We have cited the SRS Land-Use Baseline Report as a reference, but due to costs of copying the color maps, we could not use the document as an appendix. However, we have added Appendix H, Relevant Maps From the Land-Use Baseline Report which has several maps. The SRS Land-Use Baseline Report can be seen at the DOE Reading and copies are available by contacting:

Christopher Noah, Land Use Coordinator
Building 773-41A
Westinghouse Savannah River Company
Aiken, South Carolina 29808
803-725-5997
Internet: chris.noah@SRS.gov

We are writing to express concern about the January 1996 draft Savannah River Site Future Use Project Report. The relationship between land use and the protection of public health and the environment is important, and related decisions should be supported by credible analysis and adequate and meaningful public involvement. Unfortunately, the draft report falls short on both of these counts.

The public participation process was designed to solicit a range of independent comments and result in a summary of those comments. Now, though, the Department of Energy (DOE) is presenting the summary as a list of "stakeholder-preferred options" and "stakeholder recommendations." These assertions are unfounded as (1) there was no consensus building effort of similar exercise to bring together the options of concerned citizens into a single set of recommendations, and (2) the catalog of public comments in the draft report makes it clear that there was disagreement on the so-called recommendations.

Perhaps the most significant, and troubling, so-called recommendations are those two that prohibit residential land use. Despite the strong wording of the recommendations themselves, the draft report makes it clear that this position was not favored by all participants, and the draft report even *presents a contradictory recommendation to offer the land back to former landowners if DOE decides to sell it. To presume to take the mix of comments received and portray it as a public recommendation is imprudent, if not reckless. A premature assumption that there will never again be any residential use of the SRS land could lead to a weakening or abandonment of goals for truly cleaning up contaminated portions of SRS and might even result in decision allowing contamination of land on the site.*

We do not advocate residential development of SRS land. We are very aware, however, of the importance of evaluating residential land use in environmental decision-making, and the possibility that residential development of at least part of SRS one day occur. Clearly, the risks at SRS vary significantly from the very highly contaminated burial grounds and separations areas to relatively pristine areas miles away. A blanket policy prohibiting residential development ignores the variability of risk and presumes too much from the limited and inconsistent comments received.

We urged DOE to continue public discussion of land use at SRS but not to overstate the conclusions of citizen involvement to date. Also, we ask that the final report make clear that (1) there is as yet not mechanism to prevent residential land use for the length of time contamination at SRS will pose health risks, (2) there is no clear consensus that residential use of some portion of SRS will not one day be desired or that it should be prohibited outright, (3) a residential scenario will continue to be used in risk assessment and other aspects of decision-making, and (4) land use planning will proceed with greater attention to the unique characteristics of various sections of SRS.

Finally, we reiterate by reference those of our comments submitted on November 29, 1995, which were not factored into the current draft, especially those comments regarding weaknesses in the public participation process. We also ask that you review and incorporate our related comments submitted to the Citizens Advisory Board on November 5 and 27, 1995, and January 18, 1996.

Thank you for considering these comments.

Response 54. We disagree that our analysis of the comments was not credible and we do not believe the process was flawed. It was not the intent of this document to determine what analyses would be needed to support future decisions effecting the protection of the public and the environment. Adequate analyses would be performed for each activity requiring a decision.

Your comments about residential uses is a good case in point. The report does not preclude residential scenarios in risk assessments for a contaminated unit. Alternative scenario decisions would be made by DOE and the regulators, using this report as a tool.

For additional responses to your concerns, please see Responses 4-11.

The League of Women Voters is in agreement with the analysis being sent to you by Energy Research Foundation. As an organization committed to the informed participation of citizens in their government, we are particularly concerned about the flawed public participation process on which serious decision making is being based. There is no way a true consensus could emerge when this matter has not been discussed in enough forums in a sufficient variety of South Carolina *locations to make the process available to all South Carolina citizens. I understand that most meetings have been in the Aiken area, and none in Columbia, the state capitol.*

Indeed, from our experience, we believe there is an overall deterioration of the public participation process as it relates to this site. A few problems are the following:

(1) *The concept of stakeholder is a good one. You seem to be making a worthy effort to reach out to a good ethnic and socioeconomic mix, but broader geographical outreach is needed.*

(2) *Dialogue on important issues should be accessible to all South Carolinians through meetings in a variety of locations including the state capitol. All South Carolinians are stakeholders because of the inherent danger this major nuclear site poses for a very broad area, and because the economic impact on the state as a whole.*

(3) *The whole public participation process should be re-examined. A year or more ago, there were so many meetings on so many issues, many with little substance and a waste of time from attendees perspective (and certainly a costly exercise for DOE) that it became impossible for those of us who have been following these issues for years to (a) travel to so many meetings often at great distances, (b) distinguish the important from the unimportant. Consequently, many meetings have had poor attendance. Better coordination and planning from your end is essential.*

Your consideration of these comments is greatly appreciated.

Response 55. We appreciate your input into the public participation process. We recognize that we have had numerous meetings in the recent past. We are working to consolidate public meetings to make them more effective and more meaningful. We would appreciate your input for improving these meetings, as we consolidate them.

For additional responses to your concerns, please see Response 54.

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Appendix B
(Infomation is on a diskette)

APPENDIX C

SOFTWARE QA PLANS

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SOFTWARE QA PLAN
FOR
SAVANNAH RIVER SITE
COMPOSITE ANALYSIS PROGRAM

PROJECT: WSRC General Order No. C001017P

SUBCONTRACT No: 5112-015-001-CS

Prepared For:

CDM Federal Programs Corporation
Aiken, South Carolina 29803

Prepared By:

Alara Environmental Analysis, Inc.
Pleasanton, CA 94566

March 24, 1997

ALARA ENVIRONMENTAL ANALYSIS, INC.

SOFTWARE QUALITY ASSURANCE PLAN FOR PORFLOW CODE USED IN COMPOSITE ANALYSIS PROGRAM

1.0 PURPOSE

This plan describes the steps taken by ALARA Environmental Analysis, Inc., to implement software quality assurance (SQA) procedures, developed with consideration of the CDM Federal Programs Corporation Quality Assurance Manual (CDM 1996) and the ASME NQA-2A (ASME NQA-2A-1990) for the acquired computer code PORFLOW (Runchal 1997).

2.0 SCOPE

The SQA plan applies to life-cycle phases of PORFLOW as it is used in conducting composite analyses of existing and predicted groundwater contaminant plumes at the Savannah River Site (SRS). These phases including installation, testing, operation and maintenance, and retirement of this pre-existing custom software. Configuration control and quality control procedures are also included in the plan.

3.0 TERMS/DEFINITIONS

CDM FEDERAL PC/SOFTWARE COORDINATOR

The CDM Federal PC/Software Coordinator is the person responsible for ensuring that PC systems and software at CDM Federal Programs Inc. have adequate backup, and that software quality control plans are appropriately developed.

COMPUTER APPLICATIONS SPECIALIST (CAS)

The Computer Applications Specialist is the person employed by ALARA Environmental Analysis, Inc., having overall technical responsibility for computer simulations for Composite Analysis project.

CONFIGURATION CONTROL

Configuration control is the process of identifying and defining the configuration items in the PORFLOW software system, controlling the release and change of these items throughout the system life cycle, and recording and reporting the status of configuration items and change requests.

PORFLOW

PORFLOW is a commercially-available computer code acquired by WSRC for use in simulating mass transport in the saturated portion of the subsurface. Simulation results will provide groundwater concentrations of radionuclides originating from proposed low-level waste (LLW) facilities and other pre-existing sources at the SRS. By sponsor (Westinghouse Savannah River Company) directive, it is subject to NQA-2A .

SOFTWARE

Software refers to computer programs, procedures, associated procedure manuals, computer source codes and program disks.

SOFTWARE VALIDATION

Validation of software refers to the testing of the software with respect to the accuracy of decisions or assumptions incorporated into the software.

SOFTWARE VERIFICATION

Verification of software refers to the testing of the software with respect to accuracy of numerical algorithms.

4.0 RESPONSIBILITIES FOR SQA

CDM FEDERAL PC/SOFTWARE COORDINATOR

The CDM Federal PC/Software Coordinator keeps an original copy of the version of the PORFLOW code to be used in the Composite Analysis project, and reviews the SQA plan to evaluate compliance with CDM Federal and WSRC SQA requirements.

COMPUTER APPLICATIONS SPECIALIST

The Computer Applications Specialist (CAS) for the Composite Analysis project is responsible for defining software needs. Upon acquisition, the CAS is responsible for overseeing that the software life cycle procedures are correctly implemented and for overseeing configuration control and quality control procedures. The CAS is also responsible for determining software compatibility with existing or acquired hardware and maintaining documentation of SQA procedures.

5.0 SOFTWARE LIFE CYCLE

5.1 Software Installation

Because PORFLOW is pre-existing software, installation must be preceded by tests to assure the software is complete and free of viruses that may infect the computer system on which it is installed. Backup copies of the software shall be made, and used for installation. The original copies of the software shall be stored in a location safe from theft, loss, and environmental damage by the CDM Federal PC/Software Coordinator. Installation will take place in accordance with the installation instructions provided by the developer of PORFLOW.

Once installed, the configuration control shall be initiated, in which date of installation, version installed, and installation notes are recorded in a SQA Logbook. This Logbook shall contain the name and telephone number of the CAS responsible for PORFLOW and the name and contract number of the Composite Analysis project for which it was acquired. Source code listing, software documentation and user's manuals will be stored in a location accessible to designated users of the software, and shall not be removed without permission of the CAS.

5.2 Software Testing

Testing is required to confirm that PORFLOW satisfies the objectives and requirements of the simulations to be carried out for the Composite Analysis. Verification testing, described in Section 5.2.1, below, is a demonstration of whether PORFLOW meets the requirements specified regarding function, performance, external interfaces and attributes.

5.2.1 Verification

The capabilities of PORFLOW must be verified by comparing analytical solutions of the desired simulation equations for a defined problem to PORFLOW output to evaluate the accuracy of numerical algorithms. Comparison of software simulation results with results from a previously verified versions or codes (termed benchmarking) is acceptable.

5.2.2 Validation or Benchmarking

Complete validation of PORFLOW requires data that not only test the ability of the code to predict contaminant transport under present conditions, but also test the predictability of results when perturbations are made to the groundwater system and similarly to the code. These data are not presently available, nor will they be available for the Composite Analysis project. However, benchmarking of PORFLOW results to results from software that has gained high acceptability by acknowledged experts has been carried out. These results are considered acceptable for validation of PORFLOW for the purposes of the Composite Analysis project.

5.2.3 Documentation of Testing

Results of efforts to reproduce verification tests of PORFLOW shall be recorded in the SQA Logbook which is initiated when software is installed by the CAS (Sect. 5.1).

5.3 Software Operation and Maintenance

5.3.1 Operation

Operation of PORFLOW will be conducted by personnel approved by the CAS, who in the CAS's judgement, are appropriately trained. These individuals will have access to the user's manual of the code and the SQA Logbook.

Operational tests will be performed whenever PORFLOW is installed on a different computer to be used in this project, or when configurational changes are made to the software or hardware system. The results of these tests will be documented in the SQA Logbook.

5.3.2 Maintenance

Maintenance to correct software errors or adapt to changes in software requirements or the operating environments will be made only with the CAS's approval, and documented in the SQA Logbook. Written requests for maintenance actions to WSRC will be kept in a specified location by the CAS.

5.4 Software Retirement

Because PORFLOW will be licensed to WSRC, retirement of the code will be the responsibility of WSRC.

6.0 CONFIGURATION CONTROL

6.1 Configuration Identification

A configuration baseline shall be defined for PORFLOW, described by input data sets including test cases, simulation results, and hardware as the tested and approved configuration. A labeling system will be implemented for each of these components of the system, such that each item is uniquely identified and that configurations resulting from revisions of each item are uniquely identified.

6.2 Configuration Change Control

Changes to configuration items, including the PORFLOW code, input data sets, simulation results and hardware shall be formally documented under the following guidelines.

6.2.1 Changes to PORFLOW

Changes to the baseline version of PORFLOW must be approved by the CAS. Verification testing (as described in Sect. 5.2.1) shall be performed to ensure that changes do not nullify the code testing results.

6.2.2 Changes to/Creation of Data Sets and Simulation Results

Changes to, or creation of new, data sets must be documented in a manner that uniquely identifies each set and corresponding simulation results set.

6.2.3 Changes in Hardware Configuration

Changes to hardware may affect the operation of PORFLOW. Therefore, such changes shall be reflected in the archiving, or tracking procedure, and in the documentation.

6.3 Configuration Control Documentation

Configuration control documentation shall contain the information needed to manage the PORFLOW configuration and accompanying data sets, simulation results and hardware requirements. This information shall identify the approved configuration (via a well documented naming conventions for software, data sets, and simulation results) and will be kept in the SQA Logbook. This Logbook shall be easily decipherable with respect to reflecting modifications made to the various configurations.

7.0 QUALITY CONTROL

7.1 Technical Review of Software

The CAS shall periodically review the approach and key assumptions, and evaluate input data sets to assure that QA procedures have been applied and that proper documentation is being generated throughout the life cycle of PORFLOW. When necessary, the CAS will call on others to review assumptions and input data to verify their appropriateness and accuracy.

7.2 Sign-off and Approvals

The sign-off and formal approvals on key assumptions and input data will be accomplished with cover letters transmitting the information being approved. Individuals whose approval is sought will be identified by the CAS, and will include those with particular knowledge of the specific information from both CDM Federal and WSRC, and appropriate managers.

7.3 Quality Control Documentation

Documentation of Quality Control procedures will be kept in the form of the sign-off and approval cover letters that transmit information that has submitted to these procedures. These signature forms and attached information will be kept in a separate notebook, entitled Software Quality Control Notebook.

8.0 PROBLEM REPORTING AND CORRECTIVE ACTION

A formal procedure of software problems and corrective action reporting shall be established by the CAS for PORFLOW errors and failures. The reporting system shall assure that problems and corrective actions taken are promptly reported to affected organizations, such as CDM Federal and WSRC. Problems and corrective actions shall be reported in the form of letters to affected individuals and organizations, and will be described in the SQA Logbook.

9.0 RECORDS

The following documents will be retained as records:

1) SQA Plan;
2) SQA Logbook containing information on installation, software and hardware configuration, code testing results, and maintenance actions;
3) Documentation of PORFLOW, including the user's manual; and
4) SQC Notebook including documentation of approvals on input data and major assumptions made.

10.0 REFERENCES

ASME NQA-2A-1990. 1990. Part 2.7, *Quality Assurance Requirements of Computer Software for Nuclear Facility Applications.*

CDM Federal Programs Corporation (CDM). 1996. *Quality Assurance Manual.* Rev. 7. CDM Federal Programs Corporation, Fairfax, Virginia, June 17, 1996.

Runchal, Akshai. 1997. *PORLFOW: A Model For Fluid Flow, Heat and Mass Transport in Multifluid, Mulitphase Fractured or Porous Media: User's Manual - Version 3.xx.* Analytic and Computational Research, Inc., Bel Air, California.

Prepared and Approved by: Laura McDowell-Boyer (President and CEO)

Date: April 10, 1997

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APPENDIX D

COMPUTER CODES

D.1 CODE SELECTION CRITERIA AND CONSIDERATIONS

Listed below are criteria that were considered in selecting computer codes for use in the composite analysis for the Savannah River Site General Separations Area. The first list, which follows directly, consists of absolute requirements for any code (1R = #1, Required); any code not meeting any one of these requirements was rejected.

1R. The theoretical framework of the selected computer code(s) should be based on appropriate fundamental principles of chemistry and physics (e.g., conservation of mass, momentum, and energy) and well established constitutive equations (e.g., Darcy's law, Fick's law, etc.).

2R. The selected code(s) should be verified (i.e., simulation results compared against known analytical solutions of the underlying equations) to demonstrate correctness of the source code. Such verification should be fully documented in a technical report.

3R. The selected code should be documented in a technical report and contain descriptions of: 1) model theory, governing equations and assumptions, 2) computational techniques and algorithms, and 3) example applications.

4R. All simulation codes(s) selected for use in the composite analysis must be maintained under a software QA and management program that assures that modifications and updates are traceable, auditable and documented, and that all production versions have been verified and validated.

This second list contains criteria describing attributes of computer codes that, though desirable, may not be presently attainable (1S = #1, Suggested). Consideration was given to these criteria, and justification for using a code not meeting them is given in this appendix.

1S. The code(s) should allow site- and facility-specific applications; i.e., be capable of simulating the hydrologic, geologic and/or geochemical setting of the site, as well as specific design features of the facility over time.

2S. A contaminant transport code should be capable of: 1) tracking waste inventory over time, including radioactive daughter products, and 2) computing the contaminant fluxes at designated locations as a function of driving hydrologic processes and mass transport phenomena.

3S. The code(s) should be validated (e.g., simulation results compared with field data) for a system similar to that being modeled whenever possible. Benchmarking (i.e., code-to-code comparisons) is also useful in demonstrating code capabilities.

4S. The degree of complexity of the computer code(s) should be consistent with the quantity and quality of data, and the objectives of the computation. Screening calculations and sensitivity analyses should be used to simplify conceptual models, and ultimately direct code selection.

5S. Hardware requirements for the selected code should not be exotic (i.e., codes should run on readily accessible mainframe, mini, or personal computers (PC); convertibility is highly desirable).

6S. Consideration must be given to the ease of interfacing code output with other codes. For example, it is often desirable to use a groundwater code that simulates unsaturated and saturated flow, as well as mass transport, as coupling of output from each simulation type has already been accomplished.

7S. Familiarity with the code(s) should also be a consideration in selection, in light of time constraints that may be imposed for completion of a composite analysis and the need to revise the code if problems arise.

D.2 SOURCE TERM CODE

D.2.1 General Code Description

The PATHRAE code, Version 2.2d, (Merrell, et al., 1995) was selected for use in simulation the release of radionuclides and transport to the water table. The PATHRAE code uses site specific hydrologic and environmental data to calculate radionuclide concentrations in groundwater using analytical solutions to the equations describing flow and transport. The code has been used in a wide variety of applications at sites regulated by DOE, NRC and EPA.

Development History PATHRAE originated from the PRESTO family of codes developed for the U.S. Environmental Protection Agency (USEPA) by Rogers and Associates Engineering Corporation (RAE). PATHRAE has been approved by the USEPA. PATHRAE was the primary analytical tool used in the Waste Management Activities and Groundwater Protection Environmental Impact Statement at SRS. (USDOE, 1987).

Code Attributes PATHRAE is written in ANSI Standard FORTRAN 77. The main advantage of PATHRAE is its simplicity on operation and presentation while still allowing a comprehensive set of radionuclides and pathways to be analyzed. Only the groundwater pathway was needed for the Composite Analysis.

Computer Requirements PATHRAE is a relatively small computer program written in a standard language. It will compile on virtually any machine capable of running FORTRAN programs.

Restrictions

The PATHRAE code uses one-dimensional analytical solutions to the flow and transport equations. This means that only simplified conceptual models and homogeneous hydrologic properties may be used.

D.2.2 Code Selection Basis

The code selection criteria described in Sect. D.1 of this appendix were used to select PATHRAE for use in the GSA composite analysis to calculate release to the water table. Other codes considered were RESRAD, MEPAS and GENII. PATHRAE allows for more complete control of important variables through the input data set than the other codes considered, i.e., the other codes have important parameters assigned in the source code, which makes them difficult to change. In-house familiarity with PATHRAE was also considered important.

Code Verification and Benchmarking.

The PATHRAE code was used as the basis for dose calculations in an Environmental Impact Statement on Waste Management and Groundwater Protection as SRS. As part of this process, the code was subjected to a quality assurance review (Looney et al., 1987) which included (1) review of the code documentation, history of use and previous validation and verification studies, (2) comparison of model results to alternate models using different boundary conditions, (3) comparison of model predictions to measured concentrations and (4) sensitivity analysis to identify critical parameters.

The PATHRAE code was the subject of a benchmarking study conducted by the DOE Performance Assessment Task Team (Wood et al., 1994).

D.2.3 Theoretical Framework

Governing Equations and Assumptions. Groundwater migration with discharge to a well is calculated from:

$$D = \frac{Q\exp(-\lambda(t_v + t_{wc}))\lambda_L f_0 U(DF)}{q_w}$$

(D.2-1)

where

- D = individual dose (mrem/yr)
- Q = inventory of the isotope available in a given year (Ci)
- q_w = aquifer dilution flow rate (m^3/yr)
- f_0 = fraction of inventory arriving at well from transport through the aquifer
- t_v = vertical travel time of contaminants to the aquifer (yr)
- t_{wc} = waste container lifetime (yr)
- λ = radioactive decay constant (1/yr)
- λ_L = fraction of each radionuclide leached from the inventory in a year (1/yr)
- U = annual equivalent uptake by an individual (m^3/yr)
- DF = dose conversion factor mrem/pCi)

The components of the equation are:

Waste form = $Q\exp(-\lambda\ (t_v + t_{wc}))\ \lambda_L$

Transport pathway = f_0

$$\text{Environmental uptake} = \frac{U}{q_w}(DF)$$

The term f_0 can be calculated for either dispersive or non-dispersive groundwater transport. Solving the partial differential equation which describes the non-dispersive case and factoring out the effect of radioactive decay yields the fraction of the inventory which reaches the well. The radioactive decay term is included implicitly in the radionuclide inventory, Q. Thus, f_0 is given by:

$$f_0 = 0 \quad \text{for } t \le [(t_1 - t_0) + t_v + t_{wc}]$$

$$f_0 = \frac{v_a}{LR\lambda_L}\,[1 - \exp[-\lambda_L(t - (t_1 - t_0) - t_v)]] \quad \text{for } [(t_1 - t_0) + t_v + t_{wc} < t < t_1 + t_v + t_{wc}]$$

(D.2-2)

$$f_0 = \frac{v_a}{LR\lambda_L}\,\exp(-\lambda_L(t - t_1 - t_v))[1 - \exp((-\lambda_L t_0))] \quad \text{for } [t_1 + t_v + t_{wc}] \le t$$

where

t = time (yr)

$t_0 = RL/v_a$

$t_1 = R(L+x_r)/v_a$

R = retardation factor = $1 + \frac{\rho_a}{p}k_d$

k_d = sorption coefficient in the aquifer (m^3/kg)

ρ_a = aquifer density (kg/m^3)

L = length of waste site in direction parallel to aquifer flow (m)

v_a = interstitial horizontal aquifer velocity (m/yr)

x_r = distance of groundwater flow from nearest edge of burial pits to the well (m)

p = aquifer porosity

For dispersive groundwater transport, a band release leaching model is used and f_0 is given by:

$$f_0 = \frac{1}{N}\sum_{j=0}^{N-1}[F_j(t_j) - F_j(t_j - 1/\lambda_L)] \quad \textbf{(D.2-3)}$$

where

$F_j(t)$ = 0.5 U(t) [erfc (z-) + exp(d_j) erfc (z+)]

U(t) = unit step function

$$z\pm = \frac{\sqrt{d_j}[1 \pm t/(Rt_{wj})]}{2\sqrt{t/(Rt_{wj})}}$$

t_j = $t - t_v - t_{wc} + t_{op} - (j + ½)\, t_{op}/N$

t = time from facility closure (yr)

t_v = vertical travel time to the aquifer (yr)

t_{wc} = waste container lifetime (yr)

t_{op} = time of operation of facility (yr)

d_j = distance from sector center to access location, divided by the longitudinal dispersivity

t_{wj} = water travel time from sector center to access location (yr)

N = number of mesh points in numerical integration.

The numerical integration referred to above is a means by which the point source analytical solution for dispersive transport can be extended to approximate an area source. As shown in Figure D.2-1, the disposal facility length L is divided into N sectors of equal length. A point source of the appropriate magnitude is placed at the center of each sector.

The distance d_j is proportional to the distance from the center of sector j to the access location. The point source analytical solutions are then summed over all sectors to approximate an area source.

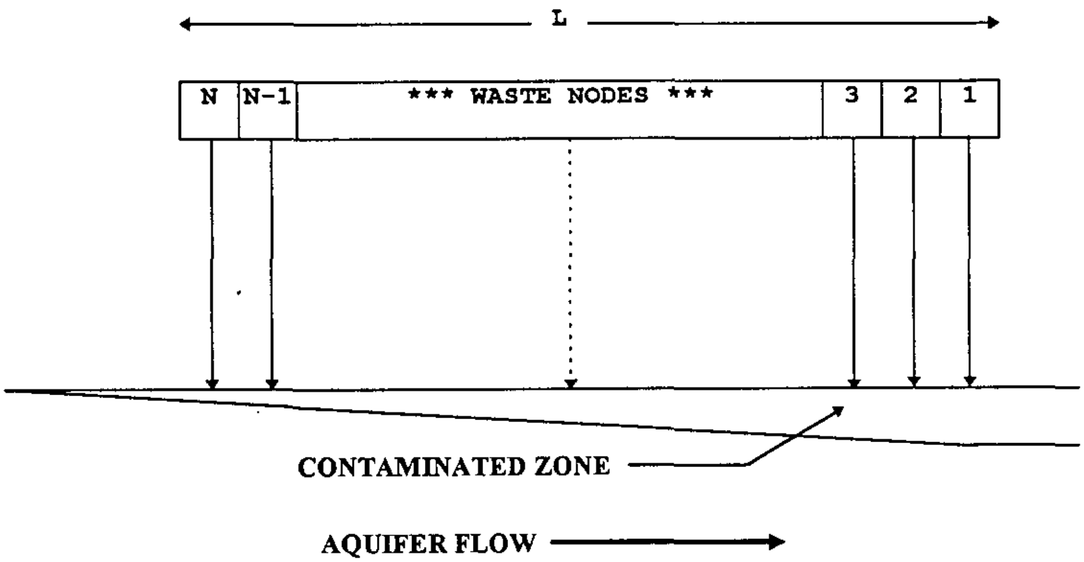

Figure D.2-1. Representation of area source term for groundwater flow.

The time, t_j, is dependent on the mesh point spacing in order to simulate the effect of placing the waste first in one end of the facility, and proceeding to the other end. Each of the mesh points is activated in sequence to model the placement of wastes during the operational period of the disposal facility.

The aquifer dilution flow rate q_w is given by:

$$q_w = WLP \text{ for } H_w > L_p \qquad \textbf{(D.2-4)}$$

$$= WL_p v_a p \text{ for } H_w < L_p$$

where

W = width of waste pit perpendicular to aquifer flow (m)

L = length of waste pit parallel to aquifer flow (m)

P = water percolation rate (m^3/m^2-yr)

L_p = length of well casing in aquifer (m)

H_w = vertical dimension of contaminated zone in aquifer (m)

v_a = horizontal velocity of aquifer (m/yr)

p = aquifer porosity

The vertical dimension of the contaminated zone, H_w, is illustrated in Figure D.2-2. It is related to the other parameters as follows:

$$H_w = \frac{PL}{pv_a}$$

(D.2-5)

As shown in Figure D.2-2, a well that intercepts the contaminated zone of the aquifer may also draw in uncontaminated water if the length of the well casing, L_p, exceeds H_w. This is why the equation for q_w gives two forms for the dilution rate based on the relative magnitudes of H_w and L_p.

In addition to modeling the effects of longitudinal dispersion in the aquifer, the well pathway can account for any transverse dispersion that may occur. This reduces the conservatism when calculating radionuclide doses for the well pathway. When modeling

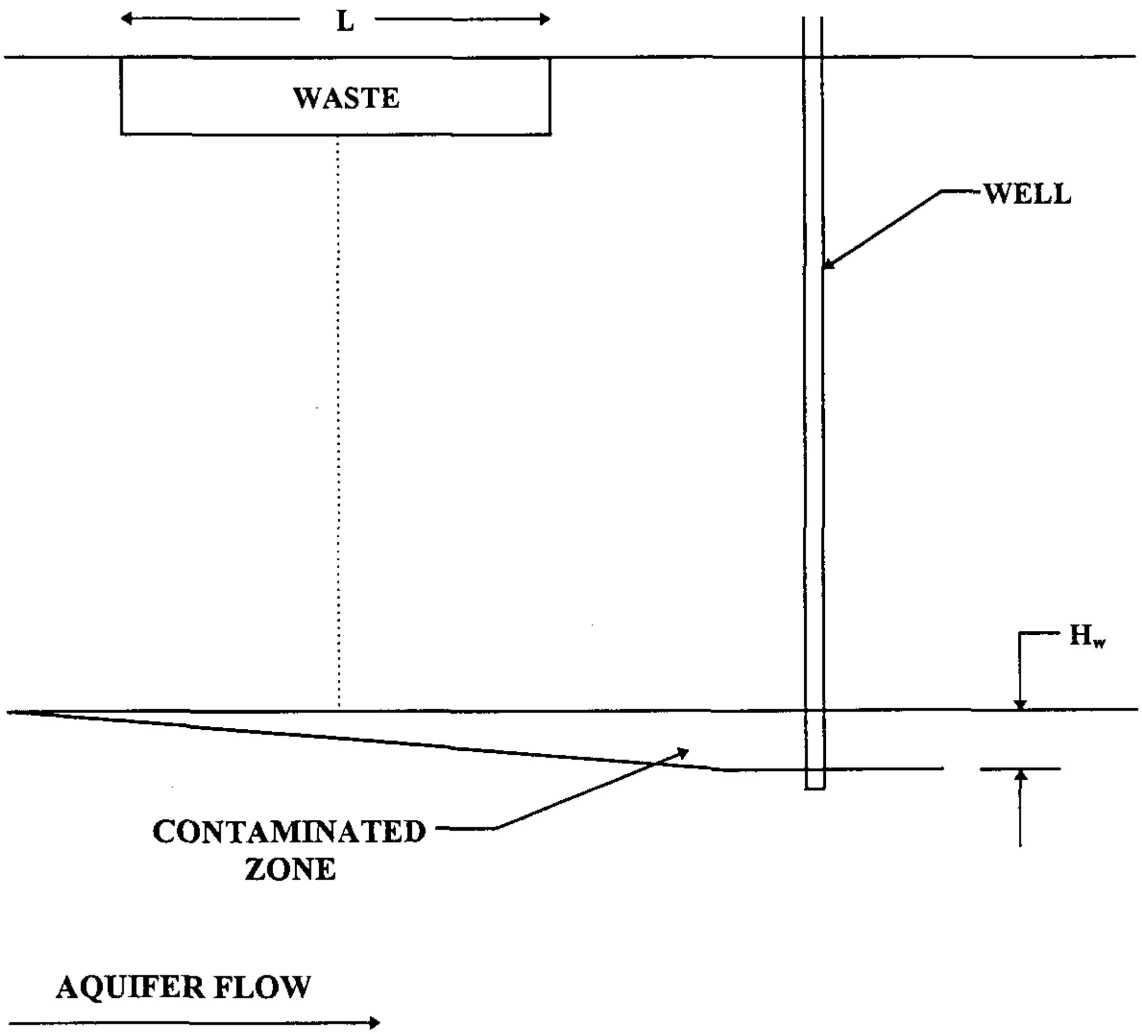

Figure D.2-2. Relationship of the well to the disposal facility

transverse dispersion the term f_0 in the equation is modified by an additional multiplicative term, f_t. This term is obtained by solving the following equation:

$$\frac{\partial ft}{\partial t} = \frac{D_y}{R}\frac{\partial^2 f_t}{\partial_y^2}$$

(D.2-6)

where the boundary conditions are:

$$f_t(y,t=0) = 1 \text{ for } |y| < \frac{W}{2}$$

$$0 \text{ for } |y| > \frac{W}{2}$$

The equation for f_t is:

$$f_t = \frac{1}{2}\mathrm{erf}\left[\frac{(y_w + W/2)\sqrt{R}}{2\sqrt{D_y t}}\right] - \frac{1}{2}erf\left[\frac{(y_w - W/2)\sqrt{R}}{2\sqrt{D_y t}}\right]$$

(D.2-7)

where

y_w = distance to well from center of waste area in the direction perpendicular to the aquifer flow (m)

D_y = transverse dispersion coefficient (m^2/yr).

For the limiting case in which D_y goes to zero, f_t becomes equal to one. Therefore, the effects of transverse dispersion can be ignored by choosing D_y equal to zero.

The groundwater pathways to the well can also accommodate vertical transport in the unsaturated zone between the waste and the aquifer. This is accomplished in the same manner as in the PRESTO-EPA and PATHRAE-EPA codes (USEPA, 1987a, USEPA,1987b). The vertical water velocity and retardation are given by:

$$V_v = I_n/(POR*S)$$

(D.2-8)

$$R = 1 + \frac{\rho}{POR * S} k_d$$

where

I_n = infiltration rate (m/yr)

S = fraction of saturation

ρ = soil density (g/cm³)

POR = soil porosity

The tern S can either be input or calculated from the expression:

$$S = S_r + (1 - S_r)\left[\frac{I_n}{P_v}\right]^{SNO}$$

(D.2-9)

where

S_r = soil residual saturation

P_v = permeability of vertical transport zone (m/yr)

SNO = an exponent representing a dimensionless soil number.

PATHRAE can also calculate the vertical transport with dispersion, in the unsaturated zone and the resulting contaminant concentrations entering the saturated zone as a function of both the time and two-dimensional position beneath the site. If this option is selected, then Equation D.2-3 is applied to the vertical unsaturated zone and Equation D.2-7 is applied to both transverse dimensions to obtain a two-dimensional, time dependent radionuclide concentration entering the unsaturated zone.

When any of the decay chains are calculated in PATHRAE it is possible to get negative arguments for the square root function. This is due to the boundary conditions imposed on the solution. The problem generally arises when the dispersivity is large and it affects only the calculation of concentrations for daughter nuclides in decay chains. When the argument of a square root is less than zero, PATHRAE decreases the dispersivity by a factor of ten for the remainder of the chain calculation. After each chain calculation the dispersivity is restored to its original value. This procedure generally does not alter the daughter radionuclide concentrations.

D.2.4 Code Inputs and Outputs

The input data for PATHRAE are read from five data files. Figure D.2-3 shows the general types of information read from the five files. The dose conversion factors and equivalent uptake factors, if appropriate, are read from the first file and are usually the same for all PATHRAE runs. The second file contains site parameters such as dimensions of the facility, cover thickness, volume of waste, etc. It also contains pathway parameters such as distance to the river and well, aquifer dispersivity, radon diffusion coefficients and meteorological data. The third data set contains distribution coefficients, leach fractions and water infiltration data. The fourth data set contains radionuclide specific data such as inventories, half-lives, gamma energies and volatility factors. The fifth data set contains food chain data such as bioconcentration factors, irrigation rates, food consumption rates and animal retention factors.

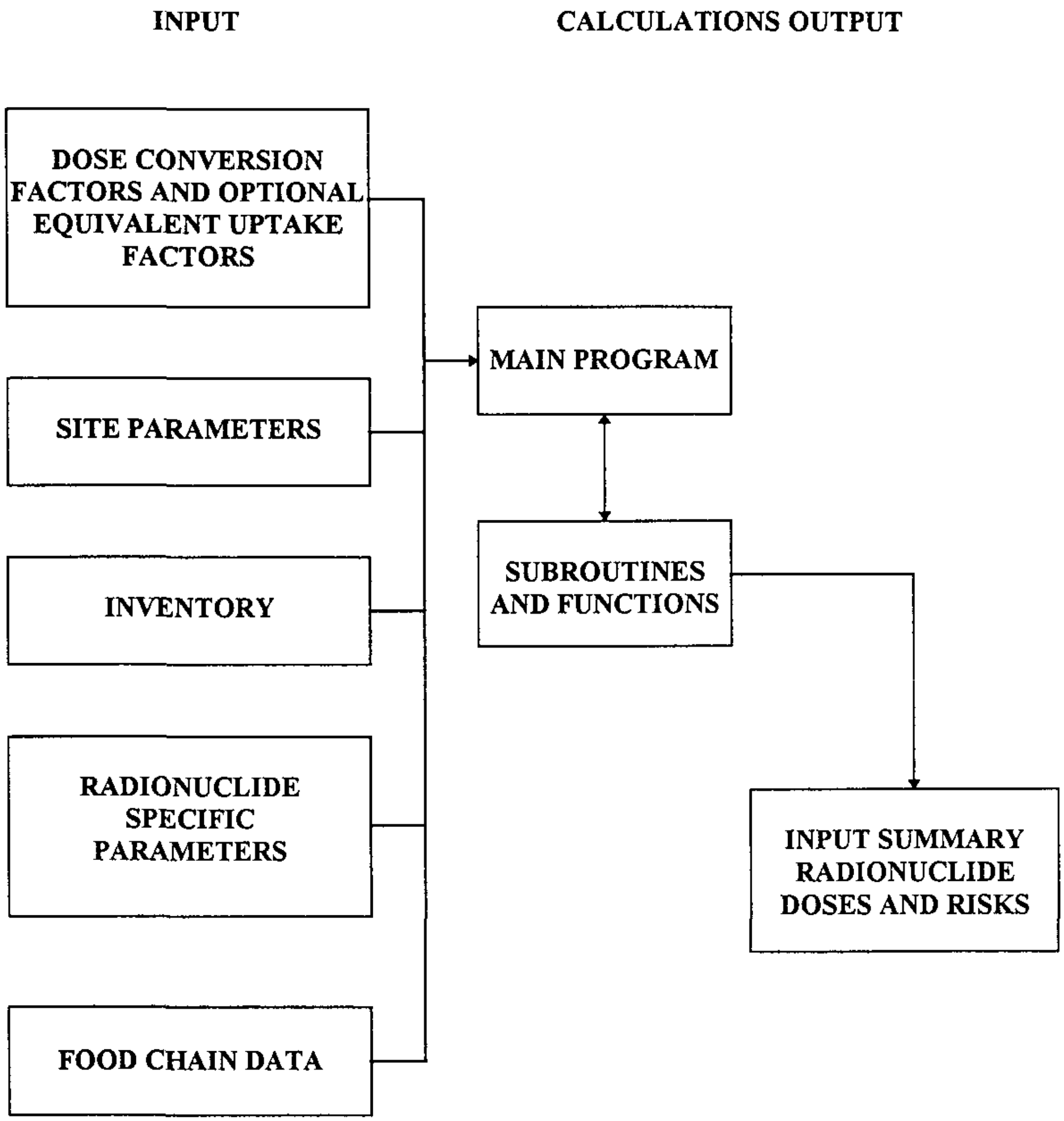

Figure D.2-3. Input and output data flow for PATHRAE

D.3 SATURATED FLOW CODE

D.3.1 General Code Description

The FACT code, Version 1.0, (Hamm et al., 1997) was selected for use in simulating the flow of groundwater in saturated media beneath the GSA and in the surrounding subsurface. The FACT code utilizes meteorological data and hydrologic data in simulating the velocities and directions of groundwater flow. These data are utilized as input to the contaminant transport code (Section D.4) for simulating contaminant transport.

Development History. FACT originated as a reduced version of the HydroGeoLogic, Inc. saturated flow code named SAFT3D, Version 1.3 (Huyakorn et al. 1991). The original FACT has been improved to include new boundary condition options, improved numerics, and a physically-based variably saturated model from VAM3DCG, Version 2.4 (Huyakorn et al. 1992).

Code Attributes. The FACT code, written in ANSI Standard FORTRAN 77, simulates flow and contaminant transport in an unconfined aquifer system whose soil moisture retention functions and relative permeability relationships do not exhibit hysteresis. Solution of the governing groundwater flow equation is approximated using the Bubnov-Galerkin finite element method, in conjunction with a symmetric Preconditioned Conjugate Gradient (ICCG) matrix solver. The code is designed specifically to handle complex multi-layer and/or heterogeneous aquifer systems, using highly efficient matrix generation and solutions techniques that allow application relatively large problem domains.

Computer Requirements. Because FACT is written in ANSI Standard FORTRAN 77, with some widely-accepted extensions, it is designed to compile and run successfully on most standard micro, mini, and mainframe computer systems with at least 2 megabytes of core memory. Up to 1.4 megabytes of disk storage per 1000 nodes in the problem domain are required for array storage.

Restrictions. Presently, the FACT code remains under development, and thus has not been released for public use.

D.3.2 Code Selection Basis

The code selection criteria described in Sect. D.1 of this appendix were used to select FACT for use in the GSA composite analysis. The three alternatives considered were:

- use PORFLOW, a variably-saturated flow and transport code used in the Performance Assessments for Z-Area and E-Area,
- use FACT, which was recently documented (Hamm et al. 1997), and
- select a new code.

Both PORFLOW and FACT meet all of the required criteria listed in Section D.1, and meet most of the suggested criteria. Therefore, because of the in-house familiarity with PORFLOW and FACT, and the availability of technical support by code authors, the alternatives were narrowed to these two codes. The FACT code was ultimately selected for use in the GSA composite analysis because of the prior work that had been completed in developing a saturated zone model of the GSA and surrounding regions. For reasons that are explained in Sect. D.4.2, PORFLOW was selected for the contaminant transport analysis, using the FACT-generated flow field as input.

Code Verification and Benchmarking. The capability of the FACT code to adequately simulated groundwater has been tested with ten documented test cases (Hamm et al. 1997). Simulation results from these test cases have been compared to analytical solutions, for the purpose of verification. Test results indicate a favorable comparison between analytical and numerical solutions by FACT. Benchmarking of the FACT code is planned, but has not been completed and documented at this time.

Code Validation. A partial validation of the flow portion of the FACT code is documented in Flach et al. (1996). In this test exercise, the FACT code was used to simulate groundwater in the vicinity of the Old Burial Grounds at SRS (within the boundaries of the GSA). The model devised was calibrated to the measured potentiometric surface of the water table aquifer (both upper and lower zones) and the Gordon aquifer. Simulated fluxes in streams compared reasonably to measured base flow in these streams. The simulated location of seepage faces compared well with the known location of seepage faces.

D.3.3 Theoretical Framework

Governing Equations and Assumptions. The governing equations for variably saturated flow that are solved by FACT are derived by combining a special form of Darcy's law (based on water phasic momentum balance) and the continuity equation for the water phase. The flow equation is

$$\nabla \cdot \left[\overline{\overline{K}} k_{rw} \nabla h \right] = \eta \frac{\partial h}{\partial t} - q \qquad \textbf{(D.3.1)}$$

where

$\overline{\overline{K}}$	=	saturated hydraulic conductivity tensor,
k_{rw}	=	relative permeability with respect to the water phase,
h	=	hydraulic head,
η	=	$C + S_w S_s$,
C	=	specific moisture capacity,
S_w	=	saturation of water,

S_s = specific storage of the reservoir formation, and

q = water source or sink term.

This relative permeability term and the water saturation term depend on soil properties, and may be expressed as follows:

$$k_{rw} = k_{rw}(S_w), \tag{D.3.2}$$

and

$$S_w = S_w(\psi), \tag{D.3.3}$$

where ψ is pressure head.

Some of the basic assumptions made in the above mathematical formulations are:

- Darcy's law is valid and hydraulic head gradients are the only significant driving force for fluid motion,
- The fluid is considered to be slightly compressible and homogeneous,
- The soil or rock medium may be represented by a single continuum porous medium of spatially variable properties,
- The porosity and saturated hydraulic conductivity are constant with time, and
- The gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.

Initial and Boundary Conditions. Boundary conditions may be specified as steady-state or time-dependent, and may be in the form of hydraulic head (Dirichlet) or fluid flux (Neumann), as well as head-dependent fluxes (mixed). A more detailed discussion on options is provided in Hamm et al. (1997).

Numerical Technique. Equation D.3.1 is approximated numerically by FACT using the traditional Bubnov-Galerkin finite element method. In this procedure, an integral approximation of the flow equation is obtained for each element within the discretized flow region using the Galerkin weighted residual criterion. The system of algebraic equations produced when boundary conditions are incorporated is solved either using the Picard method or Newton-Raphson iterative technique. A more detailed description of the numerical solutions techniques employed by FACT is proved in Hamm et al. (1997).

D.3.4 Code Inputs and Outputs

Code Input. Input data for the saturated flow model in FACT include:

- system geometry (dimensions plus layering and other heterogeneity),
- porous media properties (hydraulic conductivities, specific storage, effective porosity), and
- initial boundary conditions (prescribed head and/or flux, recharge rate).

The FACT code uses unformatted FORTRAN READ statements, such that data may occupy multiple lines in the main input file. Data groups are delineated by required comment lines.

Output Options. Primary output from the flow model of FACT includes nodal values of hydraulic head and of Darcy velocity components at user-specified time intervals. The code can create additional output files intended for graphics post-processing.

Documentation of Users Instructions. The FACT code, Version 1.0, is documented in Hamm et al. (1997). This report describes the mathematical theory and numerical techniques of this version, serves as a user's guide, and provides detailed information on the code organization, selection of computational grids and time steps, and input structure.

Test cases are also documented in this guide.

D.4 SATURATED MASS TRANSPORT CODE

D.4.1 General Code Description

The PORFLOW computer code was selected to predict radionuclide transport in the saturated subsurface. The simulation results generated by the PORFLOW code provide predictions of radionuclide plume distributions in the saturated zone and fluxes of radionuclides to the streams.

Development History. The original version of the PORFLOW code (Runchal et al. 1985) was developed to analyze the isolation performance of deep geologic repositories. This early version was limited to saturated conditions and two-dimensional porous domains, and was extensively verified and benchmarked by Eyler and Budden (1984). The code was later extended to model variably saturated flow in three-dimensions and was therefore renamed PORFLO-3, Version 1.0 (Sagar and Runchal 1990). Version 1.0 of the three-dimensional computer code was independently verified and benchmarked by Magnuson et al. (1990) against FEMWATER, FLASH, TRACR3D, and MAGNUM-2D for some applications. The code has been used in practical applications at the Hanford Site to model various waste disposal problems (Smoot and Sagar 1990), at an experimental waste trench site in Las Cruces, NM to evaluate the solute transport simulation capabilities (Rockhold and Wurstner 1991), and at the INEL to model a large organic vapor plume (Baca et al. 1988).

Newer versions of PORFLO-3 have been developed which have a number of enhancements and new options. The commercial version of PORFLO-3, which was used to model contaminant transport in the saturated zone for the composite analysis, is PORFLOW, Version 3.0 (ACRI 1996). This later version has been verified and benchmarked using test cases documented by ACRI (1994).

Code Attributes. The PORFLOW, Version 3.0, computer code is written in Fortran 77 programming language. Unique attributes of this code are

- alternate solver techniques (such as point successive over relaxation, Cholesky decomposition, Gauss elimination, and reduced system conjugate gradient) can be selected, which give the user flexibility in solving difficult problems,
- multiple contaminants may be simulated in one run, and
- radioactive daughters may be simulated, and assigned different decay and sorption properties.

The computer program is relatively portable and can be run on PCs, workstations and main-frame computers.

Computer Requirements. Practical applications of the PORFLOW code to realistic multidimensional transport problems can be made on personal computers with 486 or Pentium processors.

Restrictions. Version 2.3 of PORFLO-3 was originally developed for the U.S. DOE and is therefore in the public domain. All versions of the PORFLO-3 code are copyright protected. Commercial versions of the code, PORFLOW, which include updates of the Version 2.3, are available from Analytic and Computational Research, Inc. (ACRI), Los Angeles, California.

D.4.2 Code Selection Basis

The code selection criteria put forth in Sect. D.1 of this appendix were used to select PORFLOW for use in the GSA composite analysis. The procedure followed was to identify several codes meeting requirements 1R - 4R, and subsequently evaluate those codes in terms of the remaining eight desirable criteria (1S - 8S).

For the composite analysis, the following alternatives for selecting a code for simulating mass transport were considered:

- use PORFLOW, which was utilized in the Performance Assessments for Z-Area and E-Area,
- use the mass transport capabilities of the hydrologic code used for groundwater simulations (FACT), or
- select a new code.

PORFLOW has already been subjected to the code selection process described in Section D.1, as part of the Performance Assessment process, meeting all of the required and suggested criteria. Advantages of PORFLOW over the other two alternatives were that the user was familiar with the code, and has worked closely with the code author; PORFLOW allows simulations which consider radioactive daughter ingrowth and transport; and several contaminants may be simulated simultaneously. A recent enhancement of PORFLOW allows use of nonrectangular grids, such that flow fields from finite element codes that do not use rectangular grids can be meshed with a PORFLOW grid.

Code Verification and Benchmarking. Version 3.0 of the PORFLOW computer code has been verified by comparing the numerical solutions against known analytical solutions. The mass transport components has been verified against a number of analytical solutions for contaminant movement in steady-state flow fields. Code verification has been done using test cases that are documented in ACRI (1994).

The PORFLOW code has been benchmarked by making code-to-code comparison for various flow simulations and one mass transport simulation. A number of hypothetical situations were postulated and were simulated with PORFLOW and other independent computer codes. The hypothetical test problems were formulated to be representative of typical waste sites with realistic hydrogeologic settings. The PORFLOW code has been benchmark tested against such codes as TRACR3D (Travis 1985), FEMWATER (Yeh and Ward 1979), SUTRA (Voss 1984), and FLASH (Baca and Magnuson 1992). Results of benchmark of Version 2.5 are documented in ACRI (1994). Version 3.0 has been benchmarked by using the same test cases.

Code Validation. At the present time, the PORFLOW code has not been validated by comparison to field data. However, benchmarking results indicate that PORFLOW compares favorably with other widely accepted codes; most of which are accepted because of their perceived ability to simulate real conditions.

D.4.3 Theoretical Framework

Governing Equations and Assumptions. The governing equations solved in the PORFLOW code are based on the conservation principles of continuum mechanics. These equations describe mass transport processes in a heterogeneous and anisotropic porous medium. The equations are well accepted mathematical representations and are found in such texts as Bear and Bachmat (1990), Freeze and Cherry (1979), and Huyakorn and Pinder (1983).

The specific partial differential equation solved in PORFLOW for contaminant transport is

$$R_D \phi_D \frac{\partial C}{\partial t} + \frac{\partial}{\partial x_i}\left(V_i\ C\right) = \frac{\partial}{\partial x_i}\left[\Gamma_{ij}^{C} \frac{\partial C}{\partial x_j}\right] - \phi_D R_D \lambda C + S_C + \sum_p \phi_D R_D^p \sigma^p \lambda^p C \qquad \text{(D.4.1)}$$

where

R_D	= retardation factor,
ϕ_D	= water-filled diffusive porosity,
C	= contaminant concentration,
t	= time,
V_i	= fluid pore velocities,
x_i	= distance in ith direction,
Γ_{ij}^{C}	= hydrodynamic dispersivity tensor,
λ	= decay rate,
$S_c^{'}$	= mass source term,
$\sum_p$	= fraction of decay of the parent mass species which generates the current species, and
p	= superscript referring to the parent mass species.

The last term in equation D.4.1 represents ingrowth of mass species. The quantity R_D is defined by

$$R_D = \left[1 + \frac{(1-\theta_T)\rho_s k_d}{\phi_D} \right],$$

(D.4.2)

where

θ_t	= total porosity,

ρ_s = bulk density,

k_d = sorption coefficient,

ϕ_d = water filled diffusive porosity,

and the hyrodynamic dispersivity tensor, Γ_{ij}^{C}, is defined by

$$\Gamma^{C}_{ij} = \phi_D \tau_{ij} D_M + \phi_E D_{ij}, \tag{D.4.3}$$

where

ϕ_D = effective pore space saturated with water,

τ_{ij} = tortuosity tensor,

D_M = molecular diffusion coefficient, and

D_{ij} = mechanical dispersion tensor.

All other coefficients are as previously defined.

Some of the key assumptions that limit the applicability of the above formulation are as follows:

- contaminant concentrations are low enough that the fluid flow is independent of mass transport, i.e., concentrations do not affect the density or viscosity of the fluid;
- diffusion of the contaminants through the fluid obeys Fick's first law, where mass flux is proportional to the concentration gradient with the constant of proportionality being the diffusion coefficient;
- mechanical dispersion is described by Scheidegger's equation, (Scheidegger

1961);

- adsorption (and desorption) of contaminants onto the porous medium is
- an equilibrium process described by a linear isotherm.

Initial and Boundary Conditions. The PORFLOW code accommodates the specification of standard mathematical boundary conditions. These include: 1) Dirichlet, i.e., fixed head or concentration, 2) Neumann, i.e., specified flux, and 3) Robin, i.e., mixed, boundary conditions. Detailed information on boundary condition options is given in ACRI (1996).

Numerical Techniques. In the PORFLOW code, the governing equations for transport are solved using a method referred to as the Nodal Point Integration, a variation of the finite volume or integrated finite difference technique (ACRI 1996). In this method, the difference approximations to the governing equations are derived on a staggered grid system. The state variables are computed at the grid nodes whereas the fluxes are computed at the cell faces (located midway between adjacent grid nodes). Three discretization schemes, or basis functions to be integrated, are provided. The user may select which of the three schemes is to be used to maximize accuracy and stability.

The system of algebraic equations produced by the finite volume method are solved in the PORFLOW code using any one of five techniques

- Point successive over relaxation (Bear and Verruijt 1987),
- Alternating direction implicit (Peaceman and Rachford 1955),
- Cholesky decomposition (de Marsily 1986),
- Gauss elimination (Remson et al. 1971), or
- Reduced system conjugate gradient method (Hestenes and Stiefel 1952).

IV. Code Inputs and Outputs

Input Data Structure. Input data files for the PORFLOW code are relatively easy to prepare and check. The code uses a free-form input which allows the user to document the input data deck. The input file uses a keyword approach to define primary input data groups.

In the composite analysis application, flow fields generated by another code (the FACT code) are read by the PORFLOW as the flow field in which contaminant transport occurs. Therefore, parameters specific to flow calculations are not needed. For typical transport simulations, the data groups consist of

- Title line and comments,
- Grid specification, i.e., number and size of grid nodes in each direction,
- Lists of grid node coordinates,
- Zone definitions that specify the grid locations of distinct strata,
- Material property specifications (i.e., porosity, density),
- Convergence and iteration parameters,
- Initial concentrations,
- Boundary values and/or fluxes,
- Transport properties including effective diffusion coefficients, K_ds, and dispersivities,
- Source location and strength specifications, and
- Time step and output specifications.

Simulations of multidimensional transport can be performed in either steady-state or time-dependent mode.

Output Options. Results from the PORFLOW simulations consist of contaminant concentrations in groundwater, mass fluxes to specified nodes in the simulation domain, and information related to mass balance considerations. The user can select to print out any output variables, or can elect to post-process the data saved in files to produce graphical output.

Documentation of Users Instructions. The PORFLOW, Version 3.0, code is documented in ACRI (1996). This report describes the mathematical theory and numerical techniques of this version, serves as a user's manual, and provides detailed information on the code organization, selection of computational grids and time steps, input structure and key-word definitions.

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APPENDIX E

GENERAL SEPARATIONS AREA RESIDUAL RADIONUCLIDE INVENTORY

Lysimeter No. 1-40 Radionuclide Inventory

Lysimeter Number

Constituents	Average Analysis					Individual Resin				
	6	7	8	9	10	6	7	8	9	10
Am-241										
C-14	3.50E-01	3.50E-01	3.50E-01	3.50E-01	3.50E-01					
Ce-144	8.60E-01	8.60E-01	8.60E-01	8.60E-01	8.60E-01	1.30E-02	1.20E-02	1.10E-02	7.60E-03	5.20E-03
Co-57										6.10E-04
Co-60	2.70E-01	2.70E-01	2.70E-01	2.70E-01	2.70E-01	1.80E-01	1.70E-01	1.20E-01	8.60E-02	1.00E-01
Cs-134	2.00E-03	2.00E-03	2.00E-03	2.00E-03	2.00E-03					
Cs-137	2.30E-02	2.30E-02	2.30E-02	2.30E-02	2.30E-02	1.80E-02	1.60E-02	1.60E-02	1.10E-02	1.50E-02
Eu-154										
Mn-54	5.00E-03	5.00E-03	5.00E-03	5.00E-03	5.00E-03					1.10E-03
Na-22										
Nb-95										
Pu (ext)						2.80E-04	1.40E-04	3.60E-04	2.00E-04	8.30E-05
Pu-238										
Pu-239										
Ru-103										
Ru-106										
Sb-125										
Sc-46										
Sr-90						1.20E-02	1.10E-02	6.90E-03	6.30E-03	3.10E-03
Zn-65	8.00E-03	8.00E-03	8.00E-03	8.00E-03	8.00E-03					
Zr-95										
Gross Alpha						2.90E-04	2.90E-04	3.70E-04	2.80E-04	1.50E-04

Lysimeter No. 1-40 Radionuclide Inventory

Lysimeter Number

	1-5	11	12	13	14	15	16	17	18	19	20	21-25	26	27
Am-241							2.00E-05	7.00E-04	1.50E-05	3.20E-05	1.60E-04			
C-14														
Ce-144										9.00E-04			5.00E-02	4.00E-02
Co-57														
Co-60							2.10E-03		2.20E-04	1.00E-03	4.70E-04			
Cs-134							3.50E-03	2.70E-02	6.30E-03	2.60E-04	6.10E-04		1.70E-03	1.30E-03
Cs-137							2.30E-02	1.63E-01	3.70E-02	1.65E-03	4.10E-02	9.00E-06	5.40E-03	4.90E-03
Eu-154									1.60E-03		3.20E-03			
Mn-54														
Na-22									5.00E-05		9.70E-04			
Nb-95												3.20E-05	1.10E-02	5.70E-02
Pu (ext)														
Pu-238	2.42E+00						1.60E-01	1.60E-01	1.40E-01	1.60E-01	3.00E-01	3.70E-02		
Pu-239		3.60E-01	3.40E-01	3.60E-01	3.70E-01	3.60E-01						4.65E-03		
Ru-103									7.80E-02		9.50E-02			
Ru-106							3.50E-03	2.60E-02	3.70E-02	6.00E-04	6.10E-04		1.20E-02	1.50E-02
Sb-125							1.20E-03		4.30E-03					2.80E-03
Sc-46														
Sr-90												1.40E-05		
Zn-65														
Zr-95											1.10E-03	1.25E-05	7.70E-03	1.80E-02
Gross Alpha														

Lysimeter No. 1-40 Radionuclide Inventory

	Lysimeter Number													
	28	29	30	31	32	33	34	35	36	37	38	39	40	FINAL TOTAL (Ci)
Am-241														9.27E-04
C-14														1.75E+00
Ce-144														4.44E+00
Co-57	7.80E-02	4.00E-02	3.50E-02	3.80E-01	6.50E-01	2.90E-01	2.80E-01	3.70E-01						2.12E+00
Co-60									2.20E-01	1.70E-01	1.90E-01	2.00E-01	1.50E-01	2.94E+00
Cs-134	2.80E-03	9.90E-04	1.10E-03											5.56E-02
Cs-137	8.50E-03	4.30E-03	3.70E-03	1.60E-01	2.10E-01	1.50E-01	1.60E-01	1.40E-01						1.30E+00
Eu-154														4.80E-03
Mn-54									3.60E-02	3.10E-02	5.20E-02	6.40E-02	9.50E-03	2.19E-01
Na-22														1.02E-03
Nb-95	2.20E-02		8.40E-03	1.70E-01	2.70E-01	2.10E-01	1.30E-01	1.40E-01						1.02E+00
Pu (ext)														1.06E-03
Pu-238														3.38E+00
Pu-239														1.79E+00
Ru-103		9.10E-04			2.40E-01									4.14E-01
Ru-106	2.00E-03	1.40E-02	8.70E-03	9.00E-02	2.90E-01	2.80E-01	1.90E-01	1.50E-01						1.12E+00
Sb-125								4.10E-02						4.93E-02
Sc-46									7.40E-03	6.20E-03	9.00E-03	1.24E-02		3.50E-02
Sr-90														3.93E-02
Zn-65									7.10E-01	5.00E-01	5.60E-01	6.20E-01	1.70E-01	2.60E+00
Zr-95	2.10E-02	6.00E-03	5.20E-03	1.10E-01	2.80E-01	1.60E-01	1.00E-01	9.00E-02						7.99E-01
Gross Alpha														1.38E-03

Radionuclide Inventory
E-Area Mixed Waste Management Facility
Building No. 643-7E and 643-28E
Date: 1972 through 1988

Radionuclide Inventory
E-Area Mixed Waste Management Facility
Building No. 643-7E and 643-28E
Date: 1988 through 1996

Radionuclide	Inventory (Ci)	Radionuclide	Inventory (Ci)
Am-241	2.01E+01	Am-241	1.97E-01
Am-243	0.00E+00	Am-243	9.95E-04
C-14	1.86E+03	C-14	1.86E+03
Cf-252	1.79E+01	Cf-252	3.39E+01
Cm-244	1.82E+04	Cm-244	3.79E+03
Co-60	1.88E+06	Co-60	7.18E+04
Cs-134	2.24E+03	Cs-134	1.40E+02
Cs-137	2.29E+04	Cs-137	1.43E+03
Eu-154	1.21E+03	Eu-154	7.58E+01
Eu-155	4.37E+01	Eu-155	2.73E+00
H-3	2.06E+06	H-3	2.34E+05
I-129	9.94E-02	I-129	6.21E-03
Mn-54	2.62E+01	Mn-54	1.20E+00
Ni-59	1.74E+03	Ni-59	7.96E+01
Ni-63	2.37E+05	Ni-63	1.09E+04
Np-237	9.57E-02	Np-237	1.68E-04
Pu-238	3.97E+03	Pu-238	3.05E+02
Pu-239	6.09E+01	Pu-239	9.03E-01
Pu-240	1.51E+01	Pu-240	2.67E-01
Pu-241	6.14E+02	Pu-241	1.30E+01
Pu-242	1.25E-03	Pu-242	0.00E+00
Sb-125	1.55E+03	Sb-125	7.09E+01
Se-79	1.07E-01	Se-79	6.66E-03
Sm-151	3.11E+02	Sm-151	1.94E+01
Sn-126	1.46E-01	Sn-126	9.14E-03
Sr-90	1.81E+04	Sr-90	1.02E+03
Tc-99	3.83E+00	Tc-99	2.39E-01
Te-125m	7.16E+02	Te-125m	3.41E+01
Th-232	2.46E+00	Th-232	1.46E+00
U-233	1.55E+00	U-233	4.90E-01
U-234	2.79E+01	U-234	2.25E+01
U-235	1.06E+00	U-235	4.99E-01
U-236	4.70E+00	U-236	1.18E+00
U-238	4.16E+01	U-238	4.63E+00

Naval Fuel Waste Radionuclide Inventory

Container	Weight Total U (kg)	% Weight of Radionuclide	Radionuclide	Weight of Radionuclide (kg)	Weight of Radionuclide (g)	Activity Conversion (Ci/g)	Inventory (Ci)
Drums	24.3	0.017	U-234	0.4131	413.1	6.26E-03	2.59E+00
		0.973	U-235	23.6439	23643.9	2.16E-06	5.11E-02
		0.01	U-238	0.243	243	3.36E-07	8.17E-05
Boxes	17.6	0.017	U-234	0.2992	299.2	6.26E-03	1.87E+00
		0.973	U-235	17.1248	17124.8	2.16E-06	3.70E-02
		0.01	U-238	0.176	176	3.36E-07	5.92E-05

Radionuclide	Total Inventory (Ci)
U-234	4.46E+00
U-235	8.81E-02
U-238	1.41E-04

Note: There are 205 drums which yield a weight of 24.3 kg Total Uranium and 99 boxes which yield a weight of 17.6 kg Total Uranium.

Naval Reactor Waste Disposal Radionuclide Inventory

	KAPL CB/TS						KAPL Head					
				Total						Total		
Radionuclide	Units	Activation Ci/unit	Crud Ci/unit	Activation Ci	Crud Ci	Combined Total Ci	Units	Activation Ci/unit	Crud Ci/unit	Activation Ci	Crud Ci	Combined Total Ci
Am-241	32	3.52E-02	9.22E-06	1.13E+00	2.95E-04	1.13E+00	33		1.58E-05		5.21E-04	5.21E-04
Am-242m	32		2.24E-07		7.17E-06	7.17E-06	33		9.02E-08		2.98E-06	2.98E-06
Am-243	32	2.41E-04	8.40E-08	7.71E-03	2.69E-06	7.71E-03	33		1.35E-07		4.46E-06	4.46E-06
Ba-137m	32	5.17E-01	1.10E-03	1.65E+01	3.52E-02	1.66E+01	33		1.80E-03		5.94E-02	5.94E-02
C-14	32	1.35E+01	2.80E-02	4.32E+02	8.96E-01	4.33E+02	33	7.92E-08	4.51E-02	2.61E-06	1.49E+00	1.49E+00
Ce-144	32	4.93E-01		1.58E+01		1.58E+01	33					
Cf-249	32	1.24E-11	1.40E-14	3.97E-10	4.48E-13	3.97E-10	33		2.26E-14		7.46E-13	7.46E-13
Cf-251	32	2.64E-13	5.59E-16	8.45E-12	1.79E-14	8.47E-12	33		9.02E-16		2.98E-14	2.98E-14
Cm-242	32	5.22E-01	5.78E-05	1.67E+01	1.85E-03	1.67E+01	33		2.93E-04		9.67E-03	9.67E-03
Cm-243	32		7.00E-08		2.24E-06	2.24E-06	33		1.13E-07		3.73E-06	3.73E-06
Cm-244	32	1.92E-02	9.50E-07	6.14E-01	3.04E-05	6.14E-01	33		1.58E-05		5.21E-04	5.21E-04
Cm-245	32	1.02E-06	7.01E-10	3.26E-05	2.24E-08	3.27E-05	33		1.13E-09		3.73E-08	3.73E-08
Cm-246	32	3.93E-07	2.80E-10	1.26E-05	8.96E-09	1.26E-05	33		4.51E-10		1.49E-08	1.49E-08
Cm-247	32	7.90E-13	8.40E-16	2.53E-11	2.69E-14	2.53E-11	33		1.35E-15		4.46E-14	4.46E-14
Cm-248	32	1.86E-12	2.66E-15	5.95E-11	8.51E-14	5.96E-11	33		4.29E-15		1.42E-13	1.42E-13
Co-58	32	2.03E+03	8.00E-01	6.50E+04	2.56E+01	6.50E+04	33	3.09E-05	1.80E+01	1.02E-03	5.94E+02	5.94E+02
Co-60	32	9.82E+03	2.54E+00	3.14E+05	8.13E+01	3.14E+05	33	1.34E-03	4.51E+00	4.42E-02	1.49E+02	1.49E+02
Cr-51	32	7.49E+02	8.16E-04	2.40E+04	2.61E-02	2.40E+04	33	3.64E-03	1.13E+00	1.20E-01	3.73E+01	3.74E+01
Cs-135	32	3.47E-06		1.11E-04		1.11E-04	33					
Cs-137	32	5.17E-01	1.10E-03	1.65E+01	3.52E-02	1.66E+01	33		1.80E-03		5.94E-02	5.94E-02
Eu-154	32	6.75E-03		2.16E-01		2.16E-01	33					
Eu-155	32	3.84E-03		1.23E-01		1.23E-01	33					
Fe-55	32	8.98E+03	4.63E+00	2.87E+05	1.48E+02	2.88E+05	33	1.49E-02	9.02E+00	4.92E-01	2.98E+02	2.98E+02
Fe-59	32	7.49E+02	1.05E-02	2.40E+04	3.36E-01	2.40E+04	33	9.27E-04	1.13E+00	3.06E-02	3.73E+01	3.73E+01
H-3	32	1.35E+01	6.35E-05	4.32E+02	2.03E-03	4.32E+02	33	2.02E-05		6.67E-04		6.67E-04
Hf-181	32	7.49E+02	3.39E-03	2.40E+04	1.08E-01	2.40E+04	33		4.51E-01		1.49E+01	1.49E+01
I-129	32	8.50E-08	1.12E-07	2.72E-06	3.58E-06	6.30E-06	33		1.80E-07		5.94E-06	5.94E-06
In-113m	32	4.89E+02		1.56E+04		1.56E+04	33					
Mn-54	32	1.37E+02	1.54E-01	4.38E+03	4.93E+00	4.39E+03	33	2.75E-05	4.51E-01	9.08E-04	1.49E+01	1.49E+01
Mo-93	32	1.44E-01		4.61E+00		4.61E+00	33					
Nb-93m	32	7.49E+02	4.06E-02	2.40E+04	1.30E+00	2.40E+04	33		6.76E-02		2.23E+00	2.23E+00
Nb-94	32	6.50E-01	5.60E-04	2.08E+01	1.79E-02	2.08E+01	33	1.01E-07	9.02E-04	3.33E-06	2.98E-02	2.98E-02
Nb-95	32	1.31E+04	3.24E-02	4.19E+05	1.04E+00	4.19E+05	33		9.70E-01		3.20E+01	3.20E+01
Nb-95m	32	1.31E+02	1.28E-04	4.19E+03	4.10E-03	4.19E+03	33					
Ni-59	32	1.56E+02	8.40E-03	4.99E+03	2.69E-01	4.99E+03	33	1.22E-06	1.35E-02	4.03E-05	4.46E-01	4.46E-01
Ni-63	32	1.80E+04	8.36E-01	5.76E+05	2.68E+01	5.76E+05	33	1.49E-04	1.35E+00	4.92E-03	4.46E+01	4.46E+01
Np-237	32	4.03E-07	8.40E-10	1.29E-05	2.69E-08	1.29E-05	33		1.35E-10		4.46E-09	4.46E-09
Pm-147	32	2.98E-01		9.54E+00		9.54E+00	33					
Pu-238	32	2.69E-02	7.01E-06	8.61E-01	2.24E-04	8.61E-01	33		1.13E-05		3.73E-04	3.73E-04
Pu-239	32	1.24E-02	1.12E-06	3.97E-01	3.58E-05	3.97E-01	33		1.80E-06		5.94E-05	5.94E-05
Pu-240	32	1.11E-02	7.01E-07	3.55E-01	2.24E-05	3.55E-01	33		1.13E-06		3.73E-05	3.73E-05
Pu-241	32	3.41E+00	2.80E-04	1.09E+02	8.96E-03	1.09E+02	33		4.51E-04		1.49E-02	1.49E-02
Pu-242	32	4.07E-05	8.40E-09	1.30E-03	2.69E-07	1.30E-03	33		1.35E-08		4.46E-07	4.46E-07
Pu-244	32	2.77E-12	1.26E-15	8.86E-11	4.03E-14	8.87E-11	33		2.03E-15		6.70E-14	6.70E-14
Ru-106	32	4.20E-02		1.34E+00		1.34E+00	33					
Sb-125	32	4.08E+03	2.32E-02	1.31E+05	7.42E-01	1.31E+05	33		4.51E-02		1.49E+00	1.49E+00
Se-79	32	1.23E-04	4.20E-09	3.94E-03	1.34E-07	3.94E-03	33	3.93E-14	6.77E-09	1.30E-12	2.23E-07	2.23E-07
Sm-151	32	5.40E-03		1.73E-01		1.73E-01	33					
Sn-113	32	4.89E+02		1.56E+04		1.56E+04	33					
Sn-119m	32	8.11E+03		2.60E+05		2.60E+05	33					
Sn-123	32	2.36E+02		7.55E+03		7.55E+03	33					
Sn-126	32	7.18E-07	1.26E-08	2.30E-05	4.03E-07	2.34E-05	33		2.03E-08		6.70E-07	6.70E-07
Sr-90	32	5.27E-01	1.10E-03	1.69E+01	3.52E-02	1.69E+01	33		1.80E-03		5.94E-02	5.94E-02
Ta-182	32	1.77E+03		5.66E+04		5.66E+04	33	2.55E-03		8.42E-02		8.42E-02
Tc-99	32	1.43E-02	2.80E-05	4.58E-01	8.96E-04	4.58E-01	33	7.04E-09	4.51E-05	2.32E-07	1.49E-03	1.49E-03
Te-125m	32	2.55E+03	6.45E-03	8.16E+04	2.06E-01	8.16E+04	33		1.04E-02		3.43E-01	3.43E-01
Th-232	32	2.20E-16	2.66E-12	7.04E-15	8.51E-11	8.51E-11	33		4.29E-12		1.42E-10	1.42E-10
U-232	32	2.06E-09	4.15E-08	6.59E-08	1.33E-06	1.39E-06	33		6.77E-08		2.23E-06	2.23E-06
U-234	32	2.78E-07		8.90E-06		8.90E-06	33					
U-235	32	2.06E-08		6.59E-07		6.59E-07	33					
U-236	32	4.22E-07		1.35E-05		1.35E-05	33					
U-238	32	2.33E-06		7.46E-05		7.46E-05	33					
Y-90	32	5.27E-01	1.10E-03	1.69E+01	3.52E-02	1.69E+01	33		1.80E-03		5.94E-02	5.94E-02
Zr-93	32	7.49E+02	5.59E-06	2.40E+04	1.79E-04	2.40E+04	33		9.02E-06		2.98E-04	2.98E-04
Zr-95	32	6.18E+03	1.51E-02	1.98E+05	4.83E-01	1.98E+05	33		4.51E-01		1.49E+01	1.49E+01

Radionuclide Inventory
E-Area Old Burial Grounds
Building No. 643-E

Radionuclide	Inventory (Ci)
Am-241	2.30E+02
Am-243	No Data
C-14	3.09E+03
Cf-252	7.53E+00
Cm-244	2.54E+04
Co-60	1.66E+06
Cs-134	1.52E+04
Cs-137	1.55E+05
Eu-154	8.20E+03
Eu-155	2.95E+02
H-3	2.12E+06
I-129	6.72E-01
Mn-54	5.59E+01
Ni-59	3.71E+03
Ni-63	5.06E+05
Np-237	1.57E+00
Pu-238	1.62E+04
Pu-239	1.30E+03
Pu-240	3.11E+02
Pu-241	1.19E+04
Pu-242	No Data
Sb-125	3.30E+03
Se-79	7.21E-01
Sm-151	2.10E+03
Sn-126	9.88E-01
Sr-90	1.10E+05
Tc-99	2.59E+01
Te-125m	1.88E+03
Th-232	3.61E+00
U-233	2.33E-01
U-234	1.98E+01
U-235	6.14E-01
U-236	2.85E+00
U-238	1.57E+01

Old Solvent Tanks S1-S22
Radionuclide Inventory

Radionuclide	Total Inventory (Ci
Cs-137	1.10E+01
Cm-244	2.20E+02
Pu-238	2.75E+02
Pu-239	5.50E+01

Assume that there are 25 Ci/tank alpha emitters and 0.5 Ci/tank beta/gamma emitters

22 tanks x 25 Ci/tank = 550 Ci of alpha emitters
22 tanks x 0.5 Ci/tank = 11 Ci of beta/gamma emitters

Assume that alpha emitters are comprised of 40% Cm-244, 50% Pu-238, and 10% Pu-239

Assume that beta emitters are primarily Cs-137

Solvent Tanks S23-S30 and S-32 Radionuclide Inventory

Radionuclide	Total Inventory (Ci)
Cs-137	4.50E+00
Cm-244	9.00E+01
Pu-238	1.13E+02
Pu-239	2.25E+01

Assume that there are 25 Ci/tank alpha emitters and 0.5 Ci/tank beta/gamma emitters

9 tanks x 25 Ci/tank = 225 Ci of alpha emitters
9 tanks x 0.5 Ci/tank = 4.5 Ci of beta/gamma emitters

Assume that alpha emitters are comprised of 40% Cm-244, 50% Pu-238, and 10% Pu-239

Assume that beta emitters are primarily Cs-137

Saltstone Lysimeters--Tank 24 Radionuclide Inventory

Radionuclide	Activity Conversion (Ci/L)	Inventory (Ci)
Ag-110m	8.00E-10	2.27E-05
Am-241	1.80E-07	5.12E-03
Am-242	8.90E-11	2.53E-06
Am-242m	8.90E-11	2.53E-06
Am-243	5.30E-11	1.51E-06
C-14	8.90E-09	2.53E-04
Ce-144	4.40E-09	1.25E-04
Cm-242	8.90E-11	2.53E-06
Cm-243	3.60E-11	1.02E-06
Cm-244	8.90E-10	2.53E-05
Co-60	2.80E-07	7.96E-03
Cs-134	8.90E-08	2.53E-03
Cs-135	5.30E-11	1.51E-06
Cs-137	2.70E-05	7.67E-01
Eu-152	8.00E-09	2.27E-04
Eu-154	8.90E-07	2.53E-02
Eu-155	4.40E-07	1.25E-02
H-3	2.60E-05	7.39E-01
I-129	2.70E-08	7.67E-04
Ni-59	2.70E-10	7.67E-06
Ni-63	2.70E-08	7.67E-04
Np-237	8.00E-11	2.27E-06
Pa-234	5.30E-12	1.51E-07
Pd-107	2.70E-11	7.67E-07
Pm-147	5.40E-06	1.53E-01
Pu-238	6.70E-08	1.90E-03
Pu-239	1.70E-09	4.83E-05
Pu-240	4.40E-10	1.25E-05
Pu-241	4.40E-08	1.25E-03
Ru-106	4.50E-05	1.28E+00
Sb-125	8.90E-06	2.53E-01
Sb-126	1.80E-08	5.12E-04
Se-79	4.40E-07	1.25E-02
Sm-151	2.70E-06	7.67E-02
Sn-121m	3.60E-08	1.02E-03
Sn-126	1.80E-07	5.12E-03
Sr-90	9.30E-07	2.64E-02
Tc-99	8.90E-05	2.53E+00
Te-125m	2.70E-07	7.67E-03
Th-228	1.80E-12	5.12E-08
Th-231	1.80E-10	5.12E-06
Th-234	2.70E-12	7.67E-08
U-232	6.20E-11	1.76E-06
U-233	3.60E-12	1.02E-07
U-234	3.60E-10	1.02E-05
U-238	2.70E-12	7.67E-08
Zr-93	3.60E-10	1.02E-05
Other alpha	1.80E-07	5.12E-03
Other beta/gamma	8.90E-06	2.53E-01

Note: Assume that Lysimeters contain 7,500 gal (28,425 L) of the Nominal Blend Saltstone Solution

E-Area Trenches
Radionuclide
Inventory

Radionuclide	Inventory (Ci)
Am-241	2.57E-01
Co-60	4.63E-02
Cs-137	1.02E+01
Eu-154	*1.53E-02*
H-3	8.75E+00
I-129	1.15E-06
Np-237	8.85E-07
Pb-212	9.35E-03
Pu-238	5.16E-03
Sr-90	2.88E-01
Tc-99	9.73E-04

Note: Inventory of all 5 trenches at closure. Assume that all 5 trenches will be full in 20 years

E-Area LAW Vaults Radionuclide Inventory

Radionuclide	Estimate for 1 Vault (Ci)	Estimate for 2 Vaults (Ci)
Am-241	1.50E-01	3.01E-01
Am-243	8.67E-08	1.73E-07
Ba-137m	3.54E+01	7.08E+01
C-14	8.51E-02	1.70E-01
Ce-144	3.07E+00	6.14E+00
Cf-249	1.44E-14	2.88E-14
Cf-251	7.01E-10	1.4E-09
Cm-245	7.23E-10	1.45E-09
Cm-246	2.89E-10	5.77E-10
Cm-247	3.07E-12	6.14E-12
Cm-248	2.75E-15	5.5E-15
Co-60	4.33E+00	8.66E+00
Cs-137	1.19E+02	2.39E+02
H-3	8.30E+05	1.66E+06
I-129	2.22E-05	4.43E-05
Ni-59	5.29E-02	1.06E-01
Np-237	4.35E-03	8.69E-03
Pm-147	1.65E+01	3.31E+01
Pr-144	2.98E+00	5.96E+00
Pr-144m	1.50E-05	2.99E-05
Pu-238	3.01E+00	6.01E+00
Pu-239	6.38E-01	1.28E+00
Pu-240	1.52E-01	3.04E-01
Pu-241	7.62E+00	1.52E+01
Pu-242	1.50E-05	3.00E-05
Pu-244	1.30E-15	2.59E-15
Rh-106	3.44E-04	6.89E-04
Ru-106	8.29E-02	1.66E-01
Se-79	1.43E-02	2.85E-02
Sn-126	1.65E-04	3.31E-04
Sr-90	5.01E+01	1.00E+02
Tc-99	1.70E-02	3.41E-02
Th-232	1.59E-02	3.17E-02
U-232	1.24E-05	2.48E-05
U-233	8.75E-04	1.75E-03
U-234	3.90E-01	7.79E-01
U-235	6.17E-03	1.23E-02
U-236	1.80E-02	3.59E-02
U-238	3.14E-02	6.29E-02
Y-90	3.81E+01	7.63E+01
Zr-93	5.79E-06	1.16E-05
Other Alpha	1.30E-01	2.61E-01
Other Beta / Gamma	3.55E+01	7.10E+01

Estimate is based on LAW Vault inventory as of September 11, 1996

Assume that both vaults will be filled in 20 years.

Intermediate Level Vault
Radionuclide Inventory

Radionuclide	ILV Inventory for 1 Vault 1996 (Ci)	ILV Inventory for 2 Vaults 2016 (Ci)
Am-241	2.19E+00	4.38E+00
C-14	1.12E-03	2.24E-03
Co-60	6.92E+00	1.38E+01
Cs-137	1.26E+04	2.52E+04
H-3	4.40E+05	8.80E+05
I-129	6.94E-05	1.39E-04
Ni-59	2.83E-02	5.66E-02
Np-237	8.73E-04	1.75E-03
Pu-238	7.16E+00	1.43E+01
Pu-239	4.74E-02	9.48E-02
Pu-240	2.30E-02	4.60E-02
Pu-241	1.84E+00	3.68E+00
Pu-242	3.83E-05	7.66E-05
Se-79	3.23E-03	6.46E-03
Sn-126	4.29E-03	8.58E-03
Sr-90	7.34E+03	1.47E+04
Tc-99	1.09E-01	2.18E-01
U-233	1.28E-04	2.56E-04
U-234	5.62E-05	1.12E-04
U-235	1.50E-06	3.00E-06
U-236	2.92E-06	5.84E-06
U-238	7.73E-05	1.55E-04
Other Alpha	1.03E+00	2.06E+00
Other Beta / Gamma	9.07E-02	1.81E-01

Note: Assume that both vaults will be full in 20 years.

235-F Facility
Radionuclide Inventory

Facility	Weight (g)	Radionuclide	Ci
PuFF	772	Pu-238	9727
PEF	38	Pu-238	478
AB Line	85	Np-237	12

Total: Pu-238 = 10,205 Ci
Np-237 = 12 Ci

F-Area Separations Facilities - Raduinuclide Inventory

Facility	Source Term	Actinide Limit (kg)	Actinide	Isotropic Fraction	Weight (kg)	Weight (g)	Conversion Factor (Ci/g)	Activity (Ci)
F Canyon	U/Pu Solutions	Uranium						
		50000	U-234	0.002	1.00E+00	1.00E+03	6.26E-03	6.26E+00
		50000	U-235	0.250	1.25E+02	1.25E+05	2.16E-06	2.70E-01
		50000	U-236	0.010	5.00E+00	5.00E+03	6.47E-05	3.24E-01
		50000	U-238	99.700	4.99E+04	4.99E+07	3.36E-07	1.67E+01
		Plutonium						
		50	Pu-238	0.007	3.50E-03	3.50E+00	1.71E+01	5.99E+01
		50	Pu-239	93.410	4.67E+01	4.67E+04	6.22E-02	2.91E+03
		50	Pu-240	5.860	2.93E+00	2.93E+03	2.28E-01	6.68E+02
		50	Pu-241	0.700	3.50E-01	3.50E+02	1.03E+02	3.61E+04
		50	Pu-242	0.030	1.50E-02	1.50E+01	2.92E-03	4.38E-02
	Pu Solutioins	Plutonium						
		70	Pu-238	0.007	4.90E-03	4.90E+00	1.71E+01	8.38E+01
		70	Pu-239	93.410	6.54E+01	6.54E+04	6.22E-02	4.07E+03
		70	Pu-240	5.860	4.10E+00	4.10E+03	2.28E-01	9.35E+02
		70	Pu-241	0.700	4.90E-01	4.90E+02	1.03E+02	5.05E+04
		70	Pu-242	0.030	2.10E-02	2.10E+01	2.92E-03	6.13E-02
	Am/Cm Solution	Americium						
		10.2	Am-241	4.510	4.60E-01	4.60E+02	3.43E+00	1.58E+03
		10.2	Am-242m	0.020	2.04E-03	2.04E+00	9.72E+00	1.98E+01
		10.2	Am-243	95.470	9.74E+00	9.74E+03	1.99E-01	1.94E+03
		Curium						
		2.8	Cm-244	93.270	2.61E+00	2.61E+03	8.08E+01	2.11E+05
		2.8	Cm-245	3.570	1.00E-01	1.00E+02	1.72E-01	1.72E+01
		2.8	Cm-246	3.110	8.71E-02	8.71E+01	3.09E-01	2.69E+01
		2.8	Cm-247	0.050	1.40E-03	1.40E+00	9.04E-05	1.27E-04
	Mark 31s	Plutonium						
		70	Pu-238	0.007	4.90E-03	4.90E+00	1.71E+01	8.38E+01
		70	Pu-239	93.410	6.54E+01	6.54E+04	6.22E-02	4.07E+03
		70	Pu-240	5.860	4.10E+00	4.10E+03	2.28E-01	9.35E+02
		70	Pu-241	0.700	4.90E-01	4.90E+02	1.03E+02	5.05E+04
		70	Pu-242	0.030	2.10E-02	2.10E+01	2.92E-03	6.13E-02
	Mark 16/22s	Uranium						
		500	U-234	1.300	6.50E+00	6.50E+03	6.26E-03	4.07E+01
		500	U-235	54.800	2.74E+02	2.74E+05	2.16E-06	5.92E-01
		500	U-236	28.000	1.40E+02	1.40E+05	6.47E-05	9.06E+00
		500	U-238	15.900	7.95E+01	7.95E+04	3.36E-07	2.67E-02
		Plutonium						
		2.5	Pu-238	21.740	5.44E-01	5.44E+02	1.71E+01	9.29E+03
		2.5	Pu-239	62.050	1.55E+00	1.55E+03	6.22E-02	9.65E+01
		2.5	Pu-240	10.240	2.56E-01	2.56E+02	2.28E-01	5.84E+01
		2.5	Pu-241	5.230	1.31E-01	1.31E+02	1.03E+02	1.35E+04
		2.5	Pu-242	1.010	2.53E-02	2.53E+01	2.92E-03	7.37E-02

F-Area Separations Facilities - Radionuclide Inventory

Facility	Source Term	Actinide Limit (kg)	Actinide	Isotropic Fraction	Weight (kg)	Weight (g)	Conversion Factor (Ci/g)	Activity (Ci)
		Neptunium						
		5	Np-237	100.000	5.00E+00	5.00E+03	7.05E-04	3.53E+00
	Dissolution of	Plutonium						
	Sand, Slag, &	100	Pu-238	0.007	7.00E-03	7.00E+00	1.71E+01	1.20E+02
	Crucibles,	100	Pu-239	93.410	9.34E+01	9.34E+04	6.22E-02	5.81E+03
	Sweepings, and	100	Pu-240	5.860	5.86E+00	5.86E+03	2.28E-01	1.34E+03
	Turnings	100	Pu-241	0.700	7.00E-01	7.00E+02	1.03E+02	7.21E+04
		100	Pu-242	0.030	3.00E-02	3.00E+01	2.92E-03	8.76E-02
FB Line	Process Areas	Plutonium						
		500	Pu-238	0.007	3.50E-02	3.50E+01	1.71E+01	5.99E+02
		500	Pu-239	93.410	4.67E+02	4.67E+05	6.22E-02	2.91E+04
		500	Pu-240	5.860	2.93E+01	2.93E+04	2.28E-01	6.68E+03
		500	Pu-241	0.700	3.50E+00	3.50E+03	1.03E+02	3.61E+05
		500	Pu-242	0.030	1.50E-01	1.50E+02	2.92E-03	4.38E-01
	Vaults	Plutonium						
		1900	Pu-238	0.007	1.33E-01	1.33E+02	1.71E+01	2.27E+03
		1900	Pu-239	93.410	1.77E+03	1.77E+06	6.22E-02	1.10E+05
		1900	Pu-240	5.860	1.11E+02	1.11E+05	2.28E-01	2.54E+04
		1900	Pu-241	0.700	1.33E+01	1.33E+04	1.03E+02	1.37E+06
		1900	Pu-242	0.030	5.70E-01	5.70E+02	2.92E-03	1.66E+00

F-Area Separations Totals

Plutonium	Activity (Ci)	Curies Remaining after losure = 0.1%
Pu-238	1.25E+04	1.25E+01
Pu-239	1.56E+05	1.56E+02
Pu-240	3.60E+04	3.60E+01
Pu-241	1.95E+06	1.95E+03
Pu-242	2.43E+00	2.43E-03

Curium	Activity (Ci)	Curies Remaining after Closure = 0.1%
Cm-244	2.11E+05	2.11E+02
Cm-245	1.72E+01	1.72E-02
Cm-246	2.69E+01	2.69E-02
Cm-247	1.27E-04	1.27E-07

Uranium	Activity (Ci)	Curies Remaining after Closure = 0.1%
U-234	4.70E+01	4.70E-02
U-235	8.62E-01	8.62E-04
U-236	9.38E+00	9.38E-03
U-238	1.68E+01	1.68E-02

Americium	Activity (Ci)	Curies Remaining after Closure = 0.1%
Am-241	1.58E+03	1.58E+00
Am-242m	1.98E+01	1.98E-02
Am-243	1.94E+03	1.94E+00

Neptunium	Activity (Ci)	Curies Remaining after Closure = 0.1%
Np-237	3.53E+00	3.53E-03

Other Fission Products

7.5 Year-Old Average Fuel-Target Activity Ratios

Isotope*	Ci/Cs-137**	Ci/Pu-239***	F Canyon Ci
H-3	3.91E-03	1.48E-01	6.79E+01
C-14	1.65E-05	6.20E-04	2.85E-01
Ni-59	1.94E-05	7.31E-04	3.36E-01
Co-60	6.56E-03	2.47E-01	1.14E+02
Se-79	4.41E-06	1.66E-04	7.64E-02
Sr-90	5.36E-01	2.02E+01	9.29E+03
Y-90	5.36E-01	2.02E+01	9.29E+03
Tc-99	1.65E-04	6.20E-03	2.85E+00
Ru-106	3.43E-02	1.29E+00	5.95E+02
Rh-106	3.43E-02	1.29E+00	5.95E+02
Sn-126	5.29E-07	1.99E-05	9.17E-03
I-129	3.00E-07	1.13E-05	5.20E-03
Cs-137	1.00E+00	3.77E+01	1.73E+04
Ba-137m	9.46E-01	3.57E+01	1.64E+04
Ce-144	4.09E-02	1.54E+00	7.09E+02
Pr-144	4.09E-02	1.54E+00	7.09E+02
Pr-144m	5.89E-04	2.22E-02	1.02E+01
Pm-147	4.70E-01	1.77E+01	8.16E+03
U-233	2.87E-12	1.08E-10	4.97E-08
U-234	4.59E-05	1.73E-03	
U-235	2.00E-06	7.53E-05	
U-236	7.29E-06	2.75E-04	
U-238	1.29E-04	4.87E-03	
Np-237	3.07E-06	1.16E-04	
Pu-238	1.07E-02	4.02E-01	
Pu-239	2.65E-02	1.00E+00	1.56E+02
Pu-240	5.95E-03	2.24E-01	
Pu-241	2.19E-01	8.24E+00	
Pu-242	1.94E-07	7.31E-06	
Am-241	8.17E-04	3.08E-02	

* SRS WAC listed radionuclides with half-lives > 5 years or activity fractions > 1% of total activity
**Activity ratioed to Cs-137 at 7.5 years after irradiation averaged from Ref.1
***Activity ratioed to Pu-239 at 7.5 years after irradiation averaged from Ref 1

Reference 1. C. E. Apperson, "Mark 22 and Mark 31A Activities and Decay Heats"; DPST-83-229

Naval Fuels Material Facility
Radionuclide Inventory

Residual Inventory for 247-F

Total U	17,071 g
U-234	1.82E+00 Ci
U-235	3.59E-02 Ci
U-238	5.74E-05 Ci

F-Area Sand Filters

F-Area Sand Filters								
	Old				New			
Year	Ru-106	Cs-137	Ce-144	Pu-239	Ru-106	Cs-137	Cs-144	Pu-239
1960	6.55E+02	2.52E+02	1.09E+03	5.00E-01				
1961	9.82E+02	4.98E+02	1.55E+03	1.00E+00				
1962	1.15E+03	7.39E+02	1.74E+03	1.50E+00				
1963	1.23E+03	9.74E+02	1.82E+03	2.00E+00				
1964	1.27E+03	1.20E+03	1.85E+03	2.50E+00				
1965	1.29E+03	1.43E+03	1.87E+03	3.00E+00				
1966	1.30E+03	1.65E+03	1.87E+03	3.50E+00				
1967	1.30E+03	1.86E+03	1.88E+03	4.00E+00				
1968	1.31E+03	2.07E+03	1.88E+03	4.50E+00				
1969	1.31E+03	2.28E+03	1.88E+03	5.00E+00				
1970	1.31E+03	2.48E+03	1.88E+03	5.50E+00				
1971	1.31E+03	2.67E+03	1.88E+03	6.00E+00				
1972	1.31E+03	2.86E+03	1.88E+03	6.50E+00				
1973	1.31E+03	3.05E+03	1.88E+03	7.00E+00				
1974	1.31E+03	3.23E+03	1.88E+03	7.50E+00				
1975	9.82E+02	3.29E+03	1.33E+03	8.00E+00	3.28E+02	1.26E+02	5.46E+02	5.00E-01
1976	8.19E+02	3.34E+03	1.10E+03	8.50E+00	4.92E+02	2.49E+02	7.74E+02	1.00E+00
1977	7.37E+02	3.39E+03	1.01E+03	9.00E+00	5.74E+02	3.69E+02	8.69E+02	1.50E+00
1978	6.96E+02	3.44E+03	9.66E+02	9.50E+00	6.15E+02	4.87E+02	9.09E+02	2.00E+00
1979	6.76E+02	3.48E+03	9.50E+02	1.00E+01	6.35E+02	6.02E+02	9.26E+02	2.50E+00
1980	6.66E+02	3.53E+03	9.43E+02	1.05E+01	6.45E+02	7.14E+02	9.33E+02	3.00E+00
1981	6.61E+02	3.58E+03	9.40E+02	1.10E+01	6.50E+02	8.24E+02	9.36E+02	3.50E+00
1982	6.58E+02	3.62E+03	9.39E+02	1.15E+01	6.53E+02	9.31E+02	9.37E+02	4.00E+00
1983	6.57E+02	3.67E+03	9.38E+02	1.20E+01	6.54E+02	1.04E+03	9.37E+02	4.50E+00
1984	6.56E+02	3.71E+03	9.38E+02	1.25E+01	6.55E+02	1.14E+03	9.38E+02	5.00E+00
1985	6.56E+02	3.75E+03	9.38E+02	1.30E+01	6.55E+02	1.24E+03	9.38E+02	5.50E+00
1986	6.56E+02	3.79E+03	9.38E+02	1.35E+01	6.55E+02	1.34E+03	9.38E+02	6.00E+00
1987	6.56E+02	3.83E+03	9.38E+02	1.40E+01	6.55E+02	1.43E+03	9.38E+02	6.50E+00
1988	6.55E+02	3.87E+03	9.38E+02	1.45E+01	6.55E+02	1.53E+03	9.38E+02	7.00E+00
1989	6.55E+02	3.91E+03	9.38E+02	1.50E+01	6.55E+02	1.62E+03	9.38E+02	7.50E+00
1990	6.55E+02	3.94E+03	9.38E+02	1.55E+01	6.55E+02	1.71E+03	9.38E+02	8.00E+00
1991	3.27E+02	3.85E+03	3.92E+02		3.27E+02	1.67E+03	3.92E+02	
1992	1.64E+02	3.77E+03	1.64E+02		1.64E+02	1.63E+03	1.64E+02	
1993	8.17E+01	3.68E+03	6.83E+01		8.17E+01	1.59E+03	6.83E+01	
1994	4.08E+01	3.60E+03	2.85E+01		4.08E+01	1.56E+03	2.85E+01	
1995	2.04E+01	3.52E+03	1.19E+01		2.04E+01	1.52E+03	1.19E+01	
1996	1.02E+01	3.44E+03	4.98E+00		1.02E+01	1.49E+03	4.98E+00	
1997	5.09E+00	3.36E+03	2.08E+00		5.09E+00	1.45E+03	2.08E+00	

Totals	Ru-106	Cs-137	Ce-144	Pu-239
	1.02E+01	4.81E+03	4.16E+00	2.35E+01

Assume that each Sand Filter accumulates 0.5 Ci of alpha emitters per year and 2,000 Ci of beta-gamma emitters per year.
Assume that the alpha emitters in F Area are comprised of Pu-239 and that the beta-gamma emitters are comprised of 54.65% Ce-144, 32.75% Ru-106, and 12.605 Cs-137.

F Area and H Area Inactive Process Sewer Lines and Seepage Basin/Groundwater Operable Units

Radionuclide	F-AREA FAISL (Ci) (B-33)	F-AREA FASB/GOU (Ci) (B-18)	H-AREA HAISL (Ci) (B-33)	H-AREA HASB/GOU (Ci) (B-18)
Am-241	3.00E-02	3.29E-02	2.07E-01	3.93E-01
C-14		NA		NA
Cm-244	5.72E-02		2.72E-02	
Co-60			5.15E-01	
Cs-134			6.54E-02	
Cs-137	6.92E+01	1.49E+01	6.97E+00	1.51E+02
Eu-152	3.81E-02			
Eu-154				
Eu-155	7.63E-03			
H-3	1.11E+01		2.87E+01	
I-129		3.57E-02	1.28E-01	1.54E+00
Np-237	2.15E-02	NA		NA
Pu-238	2.72E-01	4.44E-01	3.27E-01	1.16E+00
Pu-239	2.12E+00	1.75E+00	2.94E+00	4.06E+00
Pu-240		NA		NA
Pu-241		NA		NA
Radium	8.72E-02		7.63E-02	
Ru-106	2.21E-01			
Sb-125				
Sr-89				
Sr-90	3.54E-01	1.03E+00	5.45E-01	5.35E+01
Tc-99	2.21E-01	8.80E-02		6.31E-01
Th-232	6.59E-02		7.38E-02	
U-234	7.90E-02	5.58E-02	1.91E-01	1.53E-01
U-235		1.96E-02		1.06E-01
U-236		NA		NA
U-238	8.99E-01	9.81E-02	1.91E-01	1.35E-01
Gross Alpha	5.45E+00		2.56E+00	
Gross Beta	5.18E+01		1.89E+01	

Note:
FAISL - F-Area Inactive Process Sewer Line
FASB/GOU - F-Area Seepage Basin/Groundwater Operable Unit
HAISL - H-Area Inactive Process Sewer Line
HASB/GOU - H-Area Seepage Basin/Groundwater Operable Unit

H-Area Separations Facilities - Radionuclide Inventory

Facility	Source Term	Actinide Limit (kg)	Actinide	Isotropic Fraction	Weight (kg)	Weight (g)	Conversion Factor (Ci/g)	Activity (Ci)
H Canyon	Uranium Solutions	Uranium						
		35	U-234	1.70	5.95E-01	5.95E+02	6.26E-03	3.72E+00
		35	U-235	66.20	2.32E+01	2.32E+04	2.16E-06	5.00E-02
		35	U-236	21.10	7.39E+00	7.39E+03	6.47E-05	4.78E-01
		35	U-238	11.00	3.85E+00	3.85E+03	3.36E-07	1.29E-03
	Pu-238 Solutions	Plutonium						
		10	Pu-238	83.00	8.30E+00	8.30E+03	1.71E+01	1.42E+05
		10	Pu-239	14.50	1.45E+00	1.45E+03	6.22E-02	9.02E+01
		10	Pu-240	2.10	2.10E-01	2.10E+02	2.28E-01	4.79E+01
		10	Pu-241	0.30	3.00E-02	3.00E+01	1.03E+02	3.09E+03
		10	Pu-242	0.10	1.00E-02	1.00E+01	2.92E-03	2.92E-02
	Pu-239 Solutions	Plutonium						
		120	Pu-238	0.50	6.00E-01	6.00E+02	1.71E+01	1.03E+04
		120	Pu-239	89.80	1.08E+02	1.08E+05	6.22E-02	6.70E+03
		120	Pu-240	8.50	1.02E+01	1.02E+04	2.28E-01	2.33E+03
		120	Pu-241	1.00	1.20E+00	1.20E+03	1.03E+02	1.24E+05
		120	Pu-242	0.20	2.40E-01	2.40E+02	2.92E-03	7.01E-01
	PU-242 Solutions	Plutonium						
		15	Pu-238	1.70	2.55E-01	2.55E+02	1.71E+01	4.36E+03
		15	Pu-239	1.30	1.95E-01	1.95E+02	6.22E-02	1.21E+01
		15	Pu-240	19.60	2.94E+00	2.94E+03	2.28E-01	6.70E+02
		15	Pu-241	5.80	8.70E-01	8.70E+02	1.03E+02	8.96E+04
		15	Pu-242	71.60	1.07E+01	1.07E+04	2.92E-03	3.14E+01
	Np-237	Neptunium						
		500	Np-237	100.00	5.00E+02	5.00E+05	7.05E-04	3.53E+02

H-Area Separations Facilities - Radionuclide Inventory

Facility	Source Term	Actinide Limit (kg)	Actinide	Isotropic Fraction	Weight (kg)	Weight (g)	Conversion Factor (Ci/g)	Activity (Ci)
	Mark 16/22s	Uranium						
		500	U-234	1.300	6.50E+00	6.50E+03	6.26E-03	4.07E+01
		500	U-235	54.800	2.74E+02	2.74E+05	2.16E-06	5.92E-01
		500	U-236	28.000	1.40E+02	1.40E+05	6.47E-05	9.06E+00
		500	U-238	15.900	7.95E+01	7.95E+04	3.36E-07	2.67E-02
		Plutonium						
		2.5	Pu-238	21.740	5.44E-01	5.44E+02	1.71E+01	9.29E+03
		2.5	Pu-239	62.050	1.55E+00	1.55E+03	6.22E-02	9.65E+01
		2.5	Pu-240	10.240	2.56E-01	2.56E+02	2.28E-01	5.84E+01
		2.5	Pu-241	5.230	1.31E-01	1.31E+02	1.03E+02	1.35E+04
		2.5	Pu-242	1.010	2.53E-02	2.53E+01	2.92E-03	7.37E-02
		Neptunium						
		5	Np-237	100.00	5.00E+00	5.00E+03	7.05E-04	3.53E+00
HB Line	Process Lines	Plutonium						
		10	Pu-238	83	8.30E+00	8.30E+03	1.71E+01	1.42E+05
	Outside Process Lines	Plutonium						
		50	Pu-238	83	4.15E+01	4.15E+04	1.71E+01	7.10E+05

H-Area Separations Totals

Plutonium	Activity (Ci)	Curies Remaining after Closure = 0.1%	Uranium	Activity (Ci)	Curies Remaining after Closure = 0.1%	Neptunium	Activity (Ci)	Curies Remaining after Closure = 0.1%
Pu-238	1.02E+06	1.02E+03	U-234	4.44E+01	4.44E-02	Np-237	3.56E+02	3.56E-01
Pu-239	6.90E+03	6.90E+00	U-235	6.42E-01	6.42E-04			
Pu-240	3.10E+03	3.10E+00	U-236	9.54E+00	9.54E-03			
Pu-241	1.06E+05	1.06E+02	U-238	2.80E-02	2.80E-05			
Pu-242	3.15E+01	3.15E-02						

Other Fission Products

7.5 Year-Old Average Fuel-Target Activity Ratios

Isotope*	Ci/Cs-137**	Ci/Pu-239***	H Canyon Ci
H-3	3.91E-03	1.48E-01	1.02E+00
C-14	1.65E-05	6.20E-04	4.28E-03
Ni-59	1.94E-05	7.31E-04	5.04E-03
Co-60	6.56E-03	2.47E-01	1.71E+00
Se-79	4.41E-06	1.66E-04	1.15E-03
Sr-90	5.36E-01	2.02E+01	1.39E+02
Y-90	5.36E-01	2.02E+01	1.39E+02
Tc-99	1.65E-04	6.20E-03	4.28E-02
Ru-106	3.43E-02	1.29E+00	8.92E+00
Rh-106	3.43E-02	1.29E+00	8.92E+00
Sn-126	5.29E-07	1.99E-05	1.38E-04
I-129	3.00E-07	1.13E-05	7.79E-05
Cs-137	1.00E+00	3.77E+01	2.60E+02
Ba-137m	9.46E-01	3.57E+01	2.46E+02
Ce-144	4.09E-02	1.54E+00	1.06E+01
Pr-144	4.09E-02	1.54E+00	1.06E+01
Pr-144m	5.89E-04	2.22E-02	1.53E-01
Pm-147	4.70E-01	1.77E+01	1.22E+02
U-233	2.87E-12	1.08E-10	7.46E-10
U-234	4.59E-05	1.73E-03	
U-235	2.00E-06	7.53E-05	
U-236	7.29E-06	2.75E-04	
U-238	1.29E-04	4.87E-03	
Np-237	3.07E-06	1.16E-04	
Pu-238	1.07E-02	4.02E-01	
Pu-239	2.65E-02	1.00E+00	6.90E+00
Pu-240	5.95E-03	2.24E-01	
Pu-241	2.19E-01	8.24E+00	
Pu-242	1.94E-07	7.31E-06	
Am-241	8.17E-04	3.08E-02	

* SRS WAC listed radionuclides with half-lives > 5 years or activity fractions > 1% of total activity

**Activity ratioed to Cs-137 at 7.5 years after irradiation averaged from Ref.1

***Activity ratioed to Pu-239 at 7.5 years after irradiation averaged from Ref 1

Reference 1. C. E. Apperson, "Mark 22 and Mark 31A Activities and Decay Heats"; DPST-83-229

Effluent Treatment Facility Receipt Tank
Radionuclide Inventory

Radionuclide	Activity Conversion (Ci/L)	Inventory (Ci)
Co-60	1.00E-07	1.00E-04
Cs-137	6.00E-06	6.00E-03
H-3	7.00E-05	7.00E-02
I-129	2.70E-08	2.70E-05
Pm-147	5.00E-07	5.00E-04
Pu-238	4.00E-08	4.00E-05
Pu-239	1.00E-08	1.00E-05
Ru-106	5.00E-06	5.00E-03
Sb-125	6.00E-08	6.00E-05
Sr-90	4.00E-07	4.00E-04
Te-125m	6.00E-08	6.00E-05

Note: Assume that the ETF Receipt Tank will have 1000 liters of the typical ETF waste stream *after D&D activities are completed.*

New Solvent Tanks Radionuclide Inventory
H31-H34
(Reference B-39)

Radionuclide	Total Inventory (Ci)
Cs-137	4.00E+01
Cm-244	4.00E+01
Pu-238	5.00E+01
Pu-239	1.00E+01

Assume that there are 25 Ci/tank of alpha emitters
and 10 Ci/tank of beta/gamma emitters

4 tanks x 25 Ci/tank = 100 Ci of alpha emitters
4 tanks x 10 Ci/tank = 40 Ci of beta/gamma emitters

Assume that alpha emitters are comprised of
40% Cm-244, 50% Pu-238, and 10% Pu-239

Assume that beta/gamma emitters are primarily Cs-137

H-Area Sand Filters								
	Old				New			
Year	Ru-106	Cs-137	Ce-144	Pu-238	Ru-106	Cs-137	Cs-144	Pu-238
1960	6.55E+02	2.52E+02	1.09E+03	5.00E-01				
1961	9.82E+02	4.98E+02	1.55E+03	1.00E+00				
1962	1.15E+03	7.39E+02	1.74E+03	1.50E+00				
1963	1.23E+03	9.74E+02	1.82E+03	2.00E+00				
1964	1.27E+03	1.20E+03	1.85E+03	2.50E+00				
1965	1.29E+03	1.43E+03	1.87E+03	3.00E+00				
1966	1.30E+03	1.65E+03	1.87E+03	3.50E+00				
1967	1.30E+03	1.86E+03	1.88E+03	4.00E+00				
1968	1.31E+03	2.07E+03	1.88E+03	4.50E+00				
1969	1.31E+03	2.28E+03	1.88E+03	5.00E+00				
1970	1.31E+03	2.48E+03	1.88E+03	5.50E+00				
1971	1.31E+03	2.67E+03	1.88E+03	6.00E+00				
1972	1.31E+03	2.86E+03	1.88E+03	6.50E+00				
1973	1.31E+03	3.05E+03	1.88E+03	7.00E+00				
1974	1.31E+03	3.23E+03	1.88E+03	7.50E+00				
1975	9.82E+02	3.29E+03	1.33E+03	8.00E+00	3.28E+02	1.26E+02	5.46E+02	5.00E-01
1976	8.19E+02	3.34E+03	1.10E+03	8.50E+00	4.92E+02	2.49E+02	7.74E+02	1.00E+00
1977	7.37E+02	3.39E+03	1.01E+03	9.00E+00	5.74E+02	3.69E+02	8.69E+02	1.50E+00
1978	6.96E+02	3.44E+03	9.66E+02	9.50E+00	6.15E+02	4.87E+02	9.09E+02	2.00E+00
1979	6.76E+02	3.48E+03	9.50E+02	1.00E+01	6.35E+02	6.02E+02	9.26E+02	2.50E+00
1980	6.66E+02	3.53E+03	9.43E+02	1.05E+01	6.45E+02	7.14E+02	9.33E+02	3.00E+00
1981	6.61E+02	3.58E+03	9.40E+02	1.10E+01	6.50E+02	8.24E+02	9.36E+02	3.50E+00
1982	6.58E+02	3.62E+03	9.39E+02	1.15E+01	6.53E+02	9.31E+02	9.37E+02	4.00E+00
1983	6.57E+02	3.67E+03	9.38E+02	1.20E+01	6.54E+02	1.04E+03	9.37E+02	4.50E+00
1984	6.56E+02	3.71E+03	9.38E+02	1.25E+01	6.55E+02	1.14E+03	9.38E+02	5.00E+00
1985	6.56E+02	3.75E+03	9.38E+02	1.30E+01	6.55E+02	1.24E+03	9.38E+02	5.50E+00
1986	6.56E+02	3.79E+03	9.38E+02	1.35E+01	6.55E+02	1.34E+03	9.38E+02	6.00E+00
1987	6.56E+02	3.83E+03	9.38E+02	1.40E+01	6.55E+02	1.43E+03	9.38E+02	6.50E+00
1988	6.55E+02	3.87E+03	9.38E+02	1.45E+01	6.55E+02	1.53E+03	9.38E+02	7.00E+00
1989	6.55E+02	3.91E+03	9.38E+02	1.50E+01	6.55E+02	1.62E+03	9.38E+02	7.50E+00
1990	6.55E+02	3.94E+03	9.38E+02	1.55E+01	6.55E+02	1.71E+03	9.38E+02	8.00E+00
1991	3.27E+02	3.85E+03	3.92E+02		3.27E+02	1.67E+03	3.92E+02	
1992	1.64E+02	3.77E+03	1.64E+02		1.64E+02	1.63E+03	1.64E+02	
1993	8.17E+01	3.68E+03	6.83E+01		8.17E+01	1.59E+03	6.83E+01	
1994	4.08E+01	3.60E+03	2.85E+01		4.08E+01	1.56E+03	2.85E+01	
1995	2.04E+01	3.52E+03	1.19E+01		2.04E+01	1.52E+03	1.19E+01	
1996	1.02E+01	3.44E+03	4.98E+00		1.02E+01	1.49E+03	4.98E+00	
1997	5.09E+00	3.36E+03	2.08E+00		5.09E+00	1.45E+03	2.08E+00	

Totals	Ru-106	Cs-137	Ce-144	Pu-238
	1.02E+01	4.81E+03	4.16E+00	2.35E+01

Assume that each Sand Filter accumulates 0.5 Ci of alpha emitters per year and 2,000 Ci of beta-gamma emitters per year.
Assume that the alpha emitters in H Area are comprised of Pu-238 and that the beta-gamma emitters are comprised of 54.65% Ce-144, 32.75% Ru-106, and 12.605 Cs-137.

772-F

Radioactivity Type	Ci
Pu Type 50	0.2
Pu-241	1.8
Fission Products	2.6
H-3 Labs	2.45
H-3 Floor	8.12
Pure Pu-238	0.2
Alpha Emitters in metal form	0.012

Isotopes	Ci
H-3	1.06E+01
Se-79	3.25E-06
Sr-90	4.96E-01
Tc-99	1.17E-04
Ru-106	4.50E-03
Sb-125	5.72E-07
Te-125m	2.30E-03
Sn-126	4.46E-06
I-129	3.03E-06
Cs-134	6.85E-02
Cs-137	7.00E-01
Ce-144	1.23E-03
Pm-147	6.34E-02
Sm-151	9.48E-03
Eu-154	3.70E-02
Eu-155	1.33E-03
Pu-238	2.07E-01
Pu-239	1.23E-02
Pu-240	2.90E-03
Pu-241	1.91E+00
Am-241	2.18E-03

if X = grams of WG PU, then the sum of the mass fraction times the specific activity times X for each isotope should equal the total curies of WG PU.
The equation can be solved for x.
Then x times the specific activity gives the curies of each isotope.

The equation is:

(0.96)(0.06)X + (0.06)(0.23)X + (0.005)(103)X +
(0.003)(3.40)X + (0.002)(17.1)X = Total Curies

0.631X = Total Curies

For 772-F this gives X =0.212 / 0.631 = 0.336g

For 772-1F this gives X =0.0476 / 0.631 = 0.0754g

772-1F

Radioactivity Type	Ci
Alpha Emitters	0.042
Pu-241	0.5
Beta/gamma emitters	0.21
H-3	0.1
	0
	0
Alpha Emitters in metal form	0.0056

Isotopes	Ci
H-3	1.00E-01
Se-79	2.63E-07
Sr-90	4.01E-02
Tc-99	9.44E-06
Ru-106	3.63E-04
Sb-125	4.62E-08
Te-125m	1.86E-04
Sn-126	3.61E-07
I-129	2.45E-07
Cs-134	5.53E-03
Cs-137	5.65E-02
Ce-144	9.97E-05
Pm-147	5.12E-03
Sm-151	7.66E-04
Eu-154	2.99E-03
Eu-155	1.08E-04
Pu-238	1.63E-03
Pu-239	2.75E-03
Pu-240	6.51E-04
Pu-241	5.25E-01
Am-241	4.90E-04

H-Area Tritium Facilities Radionuclide Inventory

Building	Reference	Start/Stop Date	Radionuclide	Inventory (Ci)
232 H, 233H and 234 H	B-17	1955 - 2005	H-3	30,000

Note: Assume that during D&D, 99% of all radionuclides will be removed from the facility. Assume that the residual radionuclide inventory will be equal to 10,000 Ci/building of Tritium.
There are 3 buildings; therefore, the total inventory will be equal to 30,000 Ci of Tritium.

Defense Waste Processing Facility Radionuclide Inventory

Radionuclide	Activity Conversion (Ci/gal)	Inventory (Ci)
Ag-110m	2.25E-02	2.25E+01
Am-241	1.86E-02	1.86E+01
Am-242	2.45E-05	2.45E-02
Am-242m	2.47E-05	2.47E-02
Ba-137m	2.70E+00	2.70E+03
Ce-144	1.69E+01	1.69E+04
Cm-242	6.03E-05	6.03E-02
Cm-244	2.80E-04	2.80E-01
Co-60	2.94E-01	2.94E+02
Cs-134	3.03E-01	3.03E+02
Cs-137	2.86E+00	2.86E+03
Eu-152	6.37E-03	6.37E+00
Eu-154	1.07E+00	1.07E+03
Eu-155	8.21E-01	8.21E+02
H-3	6.34E-05	6.34E-02
I-129	1.24E-05	1.24E-02
Nb-95	3.67E-05	3.67E-02
Ni-59	2.39E-03	2.39E+00
Ni-63	2.97E-01	2.97E+02
Np-237	1.52E-05	1.52E-02
Pd-107	1.57E-05	1.57E-02
Pm-147	4.15E+01	4.15E+04
Pr-144	1.69E+01	1.69E+04
Pr-144m	2.04E-01	2.04E+02
Pu-236	1.06E-04	1.06E-01

Radionuclide	Activity Conversion (Ci/gal)	Inventory (Ci)
Pu-238	1.29E+00	1.29E+03
Pu-239	1.21E-02	1.21E+01
Pu-240	7.70E-03	7.70E+00
Pu-241	1.45E+00	1.45E+03
Pu-242	1.06E-05	1.06E-02
Rh-106	2.64E+00	2.64E+03
Ru-106	2.69E+00	2.69E+03
Sb-125	1.43E+00	1.43E+03
Sb-126m	2.60E-04	2.60E-01
Se-79	2.34E-04	2.34E-01
Sm-151	4.19E-01	4.19E+02
Sn-121m	5.13E-05	5.13E-02
Sn-123	4.55E-04	4.55E-01
Sn-126	2.58E-04	2.58E-01
Sr-90	5.17E+01	5.17E+04
Tc-99	4.26E-03	4.26E+00
Te-125m	3.42E-01	3.42E+02
Te-127	1.49E-04	1.49E-01
Te-127m	1.53E-04	1.53E-01
U-232	1.46E-04	1.46E-01
U-234	4.60E-04	4.60E-01
U-236	3.34E-05	3.34E-02
Y-90	5.32E+01	5.32E+04
Zr-93	1.94E-03	1.94E+00
Zr-95	1.74E-05	1.74E-02

Note: Assume that 1000 gal of the typical sludge slurry will remain after D&D activities are completed.

Low Point Pump Pit Radionuclide Inventory

Radionuclide	Activity Conversion (Ci/gal)	Inventory (Ci)
Ag-110m	2.25E-02	1.13E+00
Am-241	1.86E-02	9.30E-01
Am-242	2.45E-05	1.23E-03
Am-242m	2.47E-05	1.24E-03
Ba-137m	2.70E+00	1.35E+02
Ce-144	1.69E+01	8.45E+02
Cm-242	6.03E-05	3.02E-03
Cm-244	2.80E-04	1.40E-02
Co-60	2.94E-01	1.47E+01
Cs-134	3.03E-01	1.52E+01
Cs-137	2.86E+00	1.43E+02
Eu-152	6.37E-03	3.19E-01
Eu-154	1.07E+00	5.35E+01
Eu-155	8.21E-01	4.11E+01
H-3	6.34E-05	3.17E-03
I-129	1.24E-05	6.20E-04
Nb-95	3.67E-05	1.84E-03
Ni-59	2.39E-03	1.20E-01
Ni-63	2.97E-01	1.49E+01
Np-237	1.52E-05	7.60E-04
Pd-107	1.57E-05	7.85E-04
Pm-147	4.15E+01	2.08E+03
Pr-144	1.69E+01	8.45E+02
Pr-144m	2.04E-01	1.02E+01
Pu-236	1.06E-04	5.30E-03

Radionuclide	Activity Conversion (Ci/gal)	Inventory (Ci)
Pu-238	1.29E+00	6.45E+01
Pu-239	1.21E-02	6.05E-01
Pu-240	7.70E-03	3.85E-01
Pu-241	1.45E+00	7.25E+01
Pu-242	1.06E-05	5.30E-04
Rh-106	2.64E+00	1.32E+02
Ru-106	2.69E+00	1.35E+02
Sb-125	1.43E+00	7.15E+01
Sb-126m	2.60E-04	1.30E-02
Se-79	2.34E-04	1.17E-02
Sm-151	4.19E-01	2.10E+01
Sn-121m	5.13E-05	2.57E-03
Sn-123	4.55E-04	2.28E-02
Sn-126	2.58E-04	1.29E-02
Sr-90	5.17E+01	2.59E+03
Tc-99	4.26E-03	2.13E-01
Te-125m	3.42E-01	1.71E+01
Te-127	1.49E-04	7.45E-03
Te-127m	1.53E-04	7.65E-03
U-232	1.46E-04	7.30E-03
U-234	4.60E-04	2.30E-02
U-236	3.34E-05	1.67E-03
Y-90	5.32E+01	2.66E+03
Zr-93	1.94E-03	9.70E-02
Zr-95	1.74E-05	8.70E-04

Note: Assume that 50 gal of the typical DWPF sludge slurry will remain in the pump pit after D&D activities are completed.

Z-Area Saltstone Disposal Facility Radionuclide Inventory

Radionuclide	Inventory (Ci)
Ag-110m	5.80E-01
Am-241	1.30E+02
Am-242	6.50E-02
Am-242m	6.50E-02
Am-243	3.90E-02
C-14	6.50E+00
Ce-144	3.20E+00
Cm-242	6.50E-02
Cm-243	2.60E-02
Cm-244	6.50E-01
Co-60	2.00E+02
Cs-134	6.50E+01
Cs-135	3.90E-02
Cs-137	2.00E+04
Eu-152	5.80E+00
Eu-154	6.50E+02
Eu-155	3.20E+02
H-3	1.90E+04
I-129	2.00E+01
Ni-59	2.00E-01
Ni-63	2.00E+01
Np-237	5.80E-02
Pa-234	3.90E-03
Pd-107	2.00E-02
Pm-147	3.90E+03

Radionuclide	Inventory (Ci)
Pu-238	4.90E+01
Pu-239	1.20E+00
Pu-240	3.20E-01
Pu-241	3.20E+01
Ru-106	3.30E+04
Sb-125	6.50E+03
Sb-126	1.30E+01
Se-79	3.20E+02
Sm-151	2.00E+03
Sn-121m	2.60E+01
Sn-126	1.30E+02
Sr-90	6.80E+02
Tc-99	6.50E+04
Te-125m	2.00E+02
Th-228	1.30E-03
Th-231	1.30E-01
Th-234	2.00E-03
U-232	4.50E-02
U-233	2.60E-03
U-234	2.60E-01
U-238	2.00E-03
Zr-93	2.60E-01
Other Alpha	1.30E+02
Other Beta/Gamma	6.50E+03

Spill Inventory

Location	Date	Description	Reference	Type Waste	Inventory (Ci)
Tank 13	12/83	Area around waste Tank 13 was contaminated when liquid radioactive waste leaked from the feed pump riser; 100 gallons of waste was spilled	B-4, B-38	Cs-137	3.15E+02
Tank 9	5/67	B242-H evaporator bottom line overflowed on top of waste Tank 9, B241-H.	B-4, B-38	Cs-137	5.53E+01
Tank 16	9/60	Fission product activity was detected in samples of water from wells around Tank 16 B241-H.	B-38	Cs-137	7.00E+02
				Sr-90	2.00E+00
				Other Beta/Gamma	1.30E+02
Tank 37	2/89	Tank 37 failed CTS line from T35 to T37	B-5, B-37	Cs-137	1.40E+03
				Sr-90	4.00E+00
				Other Beta/Gamma	2.60E+02
B281-3F	Start up to 1973	Algae flushed from walls & floors of B281-5F basin & collected in earthen retention basin B281-3F. Also received contaminated cooling water from equipment failure.	B-4	Cs-137	1.00E+01
Tank 3	8/75	Soil 2-3 feet below grade near Riser 6 on Tank 3 contaminated by seepage through cracks in concrete around jet piping	B-38	Cs-137	3.72E+01
Tank 8	4/61	Tank 8 subsurface soil mass extending 12 feet below the ground surface down to 28 feet below the surface; near the fill line entry point of Tank 8.	B-4, B-38	Cs-137	2.67E+03
B281-3H	Start up to 1973	Algae flushed from the walls and floors of the Building 281-5H Basin and collected in earthen retention basin Building 281-3H. Also received contaminated colling water from equipment failures.	B-4	Cs-137	3.00E+01

Soil/Debris Consolidated Facility Radionuclide Inventory

Radionuclide	FBSB (B-28)	FBWS (B-27)	SRLSB (B-28)	TNXBG (B-28)	Total Inventory (Ci)
H-3		3.71E-02			3.71E-02
C-14	8.72E-02	3.38E-03			9.06E-02
Na-22					—
Al-26					—
K-40	1.50E-02				1.50E-02
Sc-46					—
Cr-51					—
Mn-54					—
Fe-55					—
Fe-59					—
Co-57					—
Co-58					—
Co-60	8.97E-03	2.36E-05			8.99E-03
Ni-59		2.87E-03			2.87E-03
Ni-63					—
Zn-65					—
Se-79		7.03E-08			7.03E-08
Sr-89					—
Sr-90	8.04E-02	7.57E-03	7.08E-01		7.96E-01
Y-90					—
Zr-93					—
Zr-95	1.26E-04				1.26E-04
Nb-93m					—
Nb-94					—
Nb-95					—
Nb-95m					—
Mo-93					—
Tc-99		1.02E-03			1.02E-03
Ru-103					—
Ru-106					—
Rh-106					—
Pd-107					—
Ag-110m					—
In-113					—
Sn-113					—
Sn-119m					—
Sn-121m					—
Sn-123					—
Sn-126		8.50E-09			8.50E-09
Sb-125					—
Sb-126					—
Sb-126m					—
Te-125m					—
Te-127					—
Te-127m					—
I-129		1.30E-09			1.30E-09
Cs-134					—
CS-135					—
Cs-137	7.62E-02	1.45E-02	2.89E+00		2.98E+00
Ba-137m					—
Ce-144					—

Radionuclide	FBSB (B-28)	FBWS (B-27)	SRLSB (B-28)	TNXBG (B-28)	Total Inventory (Ci)
Pr-144					—
Pr-144m					—
Pm-147					—
Sm-151					—
Eu-152					—
Eu-154	2.60E-04	7.10E-04			9.70E-04
Eu-155	3.58E-04	1.50E-03			1.86E-03
Hf-181					—
Ta-182					—
Pb-212	5.70E-03				5.70E-03
Pb-214					—
Bi-214					—
Ra-226	2.30E-03	8.20E-04			3.12E-03
Ra-228	4.86E-03				4.86E-03
Ac-228	5.42E-03	2.40E-03			7.82E-03
Th-228	8.44E-03	2.00E-03			1.04E-02
Th-230	7.28E-03	1.20E-03			8.48E-03
Th-231					—
Th-232	6.14E-03				6.14E-03
Th-234					—
Pa-234					—
U-232					—
U-233	1.27E-03	4.02E-07			1.27E-03
U-234	1.26E-03	3.04E-07	8.00E-02	4.16E-03	8.54E-02
U-235	1.46E-04	5.06E-09	7.00E-03	3.92E-04	7.54E-03
U-236		1.51E-07			1.51E-07
U-238	2.44E-03	2.09E-06	8.00E-02	4.16E-03	8.66E-02
Np-237		4.97E-08			4.97E-08
Np-239					—
Pu-236					—
Pu-238	5.30E-03	1.70E-04	2.00E-02		2.55E-02
Pu-239	2.07E-01	4.36E-04	9.00E-02		2.97E-01
Pu-240	1.53E-03	8.67E-05			1.62E-03
Pu-241		4.82E-03			4.82E-03
Pu-242		1.13E-08			1.13E-08
Pu-244					—
Am-241	5.79E-03	5.99E-03	3.00E-02		4.18E-02
Am-242					—
Am-242m					—
Am-243					—
Cm-242					—
Cm-243					—
Cm-244					—
Cm-245					—
Cm-246					—
Cm-247					—
Cm-248					—
Cf-249					—
Cf-251					—
Cf-252					—

Note:
Radionuclides listed as Sr-90 include radionuclides reported as "Non-Volatile Beta"
Radionuclides listed as Cs-137 include radionuclides reported as "Other Beta-Gamma"
Radionuclides listed as Pu-239 include radionuclides reported as "Gross Alpha"

F- and H-Area High Level Tank Farm Radionuclide Inventory

Tank	Volume (gal)	Weight (kg)	Am-241 (Ci/kg)	Am-242m (Ci/kg)	Ba-137m (Ci/kg)	C-14 (Ci/kg)	Ce-144 (Ci/kg)	Cm-244 (Ci/kg)	Cm-246 (Ci/kg)	Co-60 (Ci/kg)	Cs-134 (Ci/kg)	Cs-135 (Ci/kg)	Cs-137 (Ci/kg)	Eu-154 (Ci/kg)	H-3 (Ci/kg)	I-129 (Ci/kg)	lAm-241 (Ci/kg)	Nb-94 (Ci/kg)	Ni-59 (Ci/kg)	Ni-63 (Ci/kg)	Np-237 (Ci/kg)	Pm-147 (Ci/kg)	Pr-144 (Ci/kg)	Pu-238 (Ci/kg)	Pu-239 (Ci/kg)	Pu-240 (Ci/kg)	Pu-241 (Ci/kg)	Pu-242 (Ci/kg)	Rh-106 (Ci/kg)	Ru-106 (Ci/kg)	Sb-125 (Ci/kg)	Se-79 (Ci/kg)	Sn-126 (Ci/kg)	Sr-90 (Ci/kg)	Tc-99 (Ci/kg)	Th-232 (Ci/kg)	U-232 (Ci/kg)	U-233 (Ci/kg)	U-234 (Ci/kg)	U-235 (Ci/kg)	U-236 (Ci/kg)	U-238 (Ci/kg)	Y-90 (Ci/kg)
1	100	88.6	1.51E-01	1.93E-04	3.38E+00	1.46E-06	1.01E-09	3.98E-05	3.27E-11	5.26E-02	1.93E-05	1.32E-05	3.57E+00	1.47E-01	0.00E+00	9.52E-08	1.84E-02	0.00E+00	1.89E-03	0.00E+00	5.62E-05	1.51E-01	1.01E-09	0.00E+00	1.16E-02	2.60E-03	4.38E-03	5.36E-07	1.60E-07	1.60E-07	9.92E-03	1.15E-03	2.15E-03	5.11E+01	2.00E-02	0.00E+00	9.58E-07	0.00E+00	0.00E+00	1.55E-06	0.00E+00	3.85E-05	5.11E+01
2	100	88.6	9.48E-02	1.18E-04	1.87E+00	2.72E-06	3.06E-13	1.99E-05	2.09E-11	1.36E-02	9.39E-07	8.46E-06	1.98E+00	5.59E-02	0.00E+00	8.09E-08	1.58E-02	0.00E+00	1.17E-03	0.00E+00	1.34E-04	1.35E-02	3.06E-13	0.00E+00	1.25E-02	2.78E-03	2.73E-03	5.75E-07	3.56E-10	3.56E-10	9.65E-04	7.39E-04	1.37E-03	2.81E+01	1.28E-02	0.00E+00	5.93E-07	0.00E+00	0.00E+00	5.14E-07	0.00E+00	1.28E-05	2.81E+01
3	100	88.6	4.21E-02	5.26E-05	8.67E-01	1.20E-06	2.80E-12	9.51E-06	9.26E-12	7.91E-03	9.39E-07	3.74E-06	9.17E-01	2.89E-02	0.00E+00	2.70E-08	1.14E-02	0.00E+00	5.20E-04	0.00E+00	1.22E-04	1.10E-02	2.60E-12	0.00E+00	7.69E-03	1.71E-03	2.40E-03	3.54E-07	1.22E-09	1.22E-09	7.62E-04	3.27E-04	6.06E-04	1.30E+01	5.56E-03	0.00E+00	2.66E-07	0.00E+00	0.00E+00	6.54E-07	0.00E+00	1.64E-05	1.30E+01
4	100	88.6	1.66E-01	2.18E-04	4.42E+00	7.50E-06	1.45E-04	5.98E-05	3.53E-11	2.26E-01	1.34E-03	1.43E-05	4.67E+00	3.36E-01	0.00E+00	1.03E-07	1.89E-02	0.00E+00	1.75E-03	0.00E+00	4.47E-05	3.84E+00	1.45E-04	0.00E+00	8.94E-03	1.99E-03	8.49E-03	4.11E-07	1.31E-03	1.31E-03	2.19E-01	1.25E-03	2.32E-03	8.76E+01	2.16E-02	0.00E+00	1.11E-06	0.00E+00	0.00E+00	1.16E-06	0.00E+00	5.00E-06	8.76E+01
5	100	88.6	1.26E-01	1.62E-04	3.03E+00	1.21E-06	1.71E-08	3.75E-05	2.71E-11	8.89E-02	5.29E-05	1.10E-06	3.20E+00	1.80E-01	0.00E+00	7.89E-08	1.76E-02	0.00E+00	1.40E-03	0.00E+00	7.57E-05	3.18E-01	1.71E-08	0.00E+00	8.71E-03	2.07E-03	4.70E-03	6.14E-07	1.43E-08	1.43E-08	2.01E-02	9.58E-04	1.78E-03	4.81E+01	1.96E-02	0.00E+00	8.22E-07	0.00E+00	0.00E+00	1.89E-06	0.00E+00	4.48E-05	4.81E+01
6	100	88.6	2.46E-01	3.19E-04	6.19E+00	0.00E+00	3.12E-07	7.95E-05	5.23E-11	1.78E-01	2.09E-04	2.11E-05	6.56E+00	3.70E-01	0.00E+00	1.52E-07	2.97E-02	0.00E+00	2.58E-03	0.00E+00	2.14E-05	1.08E+00	3.12E-07	0.00E+00	8.30E-03	2.18E-03	9.94E-03	4.31E-06	1.41E-05	1.41E-05	8.66E-02	1.85E-03	3.44E-03	9.44E+01	3.19E-02	0.00E+00	1.80E-06	0.00E+00	0.00E+00	1.65E-06	0.00E+00	6.16E-05	9.44E+01
7	100	88.6	2.17E-02	2.75E-05	4.99E-01	2.27E-06	1.30E-10	5.73E-06	4.99E-12	6.79E-03	2.22E-06	2.02E-06	5.27E-01	2.01E-02	0.00E+00	1.45E-08	1.87E-02	0.00E+00	3.65E-04	0.00E+00	2.12E-05	1.77E-02	1.30E-10	0.00E+00	9.23E-03	2.20E-03	5.63E-03	7.11E-07	1.90E-08	1.90E-08	1.17E-03	1.76E-04	3.26E-04	7.53E+00	3.05E-03	0.00E+00	1.64E-07	0.00E+00	0.00E+00	9.56E-07	0.00E+00	2.31E-05	7.53E+00
8	100	88.6	4.59E-02	6.01E-05	1.26E+00	1.89E-06	5.34E-08	1.66E-05	1.00E-11	5.17E-02	1.33E-04	4.04E-06	1.35E+00	8.92E-02	0.00E+00	2.91E-08	2.49E-02	0.00E+00	5.91E-04	0.00E+00	1.79E-05	5.14E-01	5.34E-06	0.00E+00	1.12E-02	2.63E-03	1.64E-02	3.34E-06	5.16E-05	5.16E-05	3.06E-02	3.53E-04	6.57E-04	1.92E+01	6.11E-03	0.00E+00	3.35E-07	0.00E+00	0.00E+00	8.43E-07	0.00E+00	3.91E-06	1.92E+01
9	100	88.6	1.06E-01	1.33E-04	2.10E+00	3.05E-06	3.35E-13	2.24E-05	2.35E-11	1.52E-02	1.05E-06	9.50E-06	2.22E+00	8.26E-02	0.00E+00	6.84E-08	5.14E-03	0.00E+00	1.32E-03	0.00E+00	1.32E-04	1.51E-02	3.38E-13	0.00E+00	4.10E-03	9.15E-04	8.88E-04	1.89E-07	3.92E-10	3.92E-10	1.08E-03	8.30E-04	1.54E-03	3.18E+01	1.44E-02	0.00E+00	6.66E-07	0.00E+00	0.00E+00	7.77E-07	0.00E+00	1.94E-05	3.18E+01
10	100	88.6	5.24E-02	6.54E-05	1.07E+00	1.49E-06	5.13E-13	1.73E-05	9.08E-10	8.93E-03	1.08E-06	4.74E-06	1.13E+00	3.77E-02	0.00E+00	3.38E-08	1.30E-02	0.00E+00	8.61E-04	0.00E+00	1.36E-04	9.27E-03	5.13E-13	0.00E+00	9.77E-03	2.18E-03	2.37E-03	4.50E-07	3.67E-10	3.67E-10	6.46E-04	4.14E-04	7.56E-04	1.62E+01	7.16E-03	0.00E+00	3.23E-07	0.00E+00	0.00E+00	7.07E-07	0.00E+00	1.76E-05	1.62E+01
11	100	88.6	6.21E-02	7.46E-05	2.80E+00	1.38E-06	4.01E-05	5.32E-04	4.70E-08	2.54E-01	2.97E-03	8.78E-06	2.98E+00	8.35E-01	0.00E+00	4.60E-08	4.89E-01	0.00E+00	1.42E-03	0.00E+00	9.59E-06	8.75E-01	4.01E-05	1.18E+00	1.29E-02	8.07E-03	2.68E-01	1.72E-06	7.32E-05	7.32E-05	3.15E-02	7.64E-04	7.18E-04	5.44E+01	1.33E-02	1.24E-07	1.50E-09	1.77E-05	1.45E-06	2.74E-07	2.24E-06	3.08E-07	5.44E+01
12	100	88.6	7.28E-02	8.70E-05	2.89E+00	1.57E-06	2.45E-07	4.97E-04	4.95E-08	1.72E-01	7.73E-04	9.88E-06	3.06E+00	8.79E-01	0.00E+00	5.29E-08	2.17E-01	0.00E+00	1.59E-03	0.00E+00	4.70E-05	3.26E-01	2.45E-07	7.19E-01	1.37E-02	7.58E-03	9.59E-02	1.10E-06	2.24E-06	2.24E-06	1.24E-02	6.81E-04	8.54E-04	5.52E+01	1.49E-02	8.06E-08	4.51E-06	2.27E-04	2.12E-05	3.99E-07	1.66E-06	4.02E-06	5.52E+01
13	100	88.6	3.41E-02	4.14E-05	1.11E+00	8.08E-07	5.65E-08	1.42E-04	1.50E-08	4.02E-02	1.54E-04	4.19E-06	1.18E+00	1.85E-01	0.00E+00	2.47E-08	3.35E-02	0.00E+00	6.18E-04	0.00E+00	3.70E-05	7.02E-02	5.85E-08	1.10E-01	3.65E-03	1.51E-03	9.28E-03	1.00E-06	4.78E-07	4.78E-07	2.79E-03	3.72E-04	4.58E-04	2.01E+01	8.34E-03	4.97E-07	1.00E-07	1.02E-04	1.44E-05	3.93E-07	1.48E-06	4.59E-06	2.01E+01
14	100	88.6	1.53E-01	1.90E-04	3.44E+00	3.63E-07	7.07E-11	1.40E-04	1.46E-08	4.48E-02	1.88E-05	1.44E-05	3.84E+00	2.06E-01	0.00E+00	9.85E-08	3.08E-02	0.00E+00	1.86E-03	0.00E+00	1.32E-04	5.06E-02	7.07E-11	4.86E-02	1.45E-02	4.68E-03	7.06E-03	8.60E-07	6.26E-09	6.26E-09	3.20E-03	1.27E-03	2.12E-03	5.46E+01	2.16E-02	2.55E-08	8.08E-07	8.99E-05	1.23E-06	9.96E-07	1.06E-06	1.90E-06	5.46E+01
15	100	88.6	7.47E-02	8.81E-05	2.97E+00	1.54E-06	1.87E-08	3.17E-04	5.68E-08	1.47E-01	5.52E-04	1.06E-05	3.14E+00	6.44E-01	0.00E+00	5.55E-08	1.01E-01	0.00E+00	1.71E-03	0.00E+00	2.34E-05	2.40E-01	1.87E-08	3.19E-01	8.01E-03	3.67E-03	2.87E-02	2.93E-06	4.00E-06	4.00E-06	9.14E-03	9.47E-04	8.67E-04	5.72E+01	1.80E-02	7.47E-08	0.00E+00	9.13E-05	2.50E-05	4.03E-07	2.36E-06	9.24E-09	5.72E+01
16	100	88.6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	2000	1772.0	0.00E+00	0.00E+00	3.11E-02	1.78E-06	7.96E-08	4.18E-07	2.49E-13	1.35E-03	3.88E-06	9.94E-08	3.29E-02	2.26E-03	0.00E+00	7.15E-10	2.23E-02	0.00E+00	1.05E-04	0.00E+00	0.00E+00	1.45E-02	7.96E-08	0.00E+00	6.24E-03	1.65E-03	1.10E-02	2.38E-06	1.28E-06	1.28E-06	6.54E-04	8.68E-06	1.61E-05	4.77E-01	1.51E-04	0.00E+00	2.87E-08	0.00E+00	0.00E+00	1.72E-07	0.00E+00	1.07E-05	4.77E-01
18	1000	886.0	0.00E+00	0.00E+00	3.55E-02	2.12E-06	9.15E-08	4.63E-07	2.95E-13	1.38E-03	4.00E-06	1.18E-07	3.75E-02	2.40E-03	0.00E+00	8.48E-10	2.28E-02	0.00E+00	1.25E-04	0.00E+00	0.00E+00	1.47E-02	9.18E-08	0.00E+00	7.26E-03	1.84E-03	1.08E-02	2.18E-06	1.43E-06	1.43E-06	6.66E-04	1.03E-05	1.91E-06	5.42E-01	1.79E-04	0.00E+00	3.11E-08	0.00E+00	0.00E+00	2.37E-07	0.00E+00	1.17E-05	5.42E-01
19	1000	886.0	0.00E+00	0.00E+00	1.56E-02	8.23E-07	2.56E-08	2.18E-07	1.15E-13	8.57E-04	2.67E-06	4.58E-08	1.65E-02	1.31E-03	0.00E+00	3.29E-10	0.00E+00	0.00E+00	4.84E-05	0.00E+00	0.00E+00	1.01E-02	2.56E-08	0.00E+00	4.30E-03	9.62E-04	1.84E-01	1.96E-06	6.07E-07	6.07E-07	5.93E-04	4.00E-06	7.44E-06	2.40E-01	6.94E-05	0.00E+00	1.28E-08	0.00E+00	0.00E+00	8.04E-08	0.00E+00	7.34E-06	2.40E-01
20	1000	886.0	0.00E+00	0.00E+00	1.56E-02	8.23E-07	2.56E-08	2.18E-07	1.15E-13	8.57E-04	2.67E-06	4.58E-08	1.65E-02	1.31E-03	0.00E+00	3.29E-10	0.00E+00	0.00E+00	4.84E-05	0.00E+00	0.00E+00	1.01E-02	2.56E-08	0.00E+00	4.30E-03	9.62E-04	1.84E-01	1.96E-06	6.07E-07	6.07E-07	5.93E-04	4.00E-06	7.44E-06	2.40E-01	6.94E-05	0.00E+00	1.28E-08	0.00E+00	0.00E+00	8.04E-08	0.00E+00	7.34E-06	2.40E-01
21	100	88.6	7.96E-03	9.70E-06	5.47E-01	1.56E-08	7.19E-06	1.13E-04	8.09E-09	7.22E-02	2.56E-03	1.51E-06	5.78E-01	2.23E-01	0.00E+00	7.91E-09	3.99E-03	0.00E+00	1.79E-04	0.00E+00	1.81E-05	5.71E-01	7.19E-05	1.51E-01	1.89E-04	1.09E-04	2.16E-03	9.20E-06	1.27E-04	1.27E-04	1.97E-02	1.35E-04	1.23E-04	1.07E+01	2.28E-03	9.78E-10	0.00E+00	2.99E-05	2.96E-05	4.07E-07	6.04E-06	2.76E-07	1.07E+01
22	100	88.6	7.92E-03	9.89E-06	5.59E-01	0.00E+00	3.66E-06	1.15E-04	8.28E-09	6.82E-02	1.98E-03	1.54E-06	5.91E-01	2.21E-01	0.00E+00	8.10E-09	0.00E+00	0.00E+00	1.78E-04	0.00E+00	1.96E-05	4.75E-01	3.66E-05	1.24E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.40E-05	7.40E-05	1.66E-02	1.38E-04	1.26E-04	1.10E+01	2.34E-03	0.00E+00	0.00E+00	8.97E-05	3.23E-05	4.93E-07	5.31E-06	7.16E-07	1.10E+01
23	1000	886.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	100	88.6	3.41E-02	4.14E-05	1.11E+00	8.08E-07	5.65E-08	1.42E-04	1.50E-08	4.02E-02	1.54E-04	4.19E-06	1.18E+00	1.85E-01	0.00E+00	2.47E-08	3.35E-02	0.00E+00	6.18E-04	0.00E+00	3.70E-05	7.02E-02	5.85E-08	1.10E-01	3.65E-03	1.51E-03	9.28E-03	1.00E-06	4.78E-07	4.78E-07	2.79E-03	3.72E-04	4.58E-04	2.01E+01	8.34E-03	4.97E-07	1.00E-07	1.02E-04	1.44E-05	3.93E-07	1.48E-06	4.59E-06	2.01E+01
25	1000	886.0	0.00E+00	0.00E+00	9.95E-02	4.01E-06	5.14E-02	1.66E-06	5.58E-13	2.09E-02	1.02E-03	2.23E-07	1.05E-01	1.65E-02	0.00E+00	1.60E-09	4.86E-02	0.00E+00	2.35E-04	0.00E+00	0.00E+00	1.42E+00	5.14E-02	0.00E+00	1.81E-02	3.60E-03	8.18E-02	7.41E-07	4.05E-02	4.05E-02	7.25E-02	1.95E-05	3.61E-05	1.55E+00	3.37E-04	0.00E+00	7.00E-08	0.00E+00	0.00E+00	1.49E-07	0.00E+00	1.36E-05	1.55E+00
26	1000	886.0	0.00E+00	0.00E+00	9.95E-02	4.01E-06	5.14E-02	1.66E-06	5.58E-13	2.09E-02	1.02E-03	2.23E-07	1.05E-01	1.65E-02	0.00E+00	1.60E-09	4.86E-02	0.00E+00	2.35E-04	0.00E+00	0.00E+00	1.42E+00	5.14E-02	0.00E+00	1.81E-02	3.60E-03	8.18E-02	7.41E-07	4.05E-02	4.05E-02	7.25E-02	1.95E-05	3.61E-05	1.55E+00	3.37E-04	0.00E+00	7.00E-08	0.00E+00	0.00E+00	1.49E-07	0.00E+00	1.36E-05	1.55E+00
27	1000	886.0	0.00E+00	0.00E+00	9.95E-02	4.01E-06	5.14E-02	1.66E-06	5.58E-13	2.09E-02	1.02E-03	2.23E-07	1.05E-01	1.65E-02	0.00E+00	1.60E-09	4.86E-02	0.00E+00	2.35E-04	0.00E+00	0.00E+00	1.42E+00	5.14E-02	0.00E+00	1.81E-02	3.60E-03	8.18E-02	7.41E-07	4.05E-02	4.05E-02	7.25E-02	1.95E-05	3.61E-05	1.55E+00	3.37E-04	0.00E+00	7.00E-08	0.00E+00	0.00E+00	1.49E-07	0.00E+00	1.36E-05	1.55E+00
28	1000	886.0	0.00E+00	0.00E+00	9.95E-02	4.01E-06	5.14E-02	1.66E-06	5.58E-13	2.09E-02	1.02E-03	2.23E-07	1.05E-01	1.65E-02	0.00E+00	1.60E-09	4.86E-02	0.00E+00	2.35E-04	0.00E+00	0.00E+00	1.42E+00	5.14E-02	0.00E+00	1.81E-02	3.60E-03	8.18E-02	7.41E-07	4.05E-02	4.05E-02	7.25E-02	1.95E-05	3.61E-05	1.55E+00	3.37E-04	0.00E+00	7.00E-08	0.00E+00	0.00E+00	1.49E-07	0.00E+00	1.36E-05	1.55E+00
29	100	88.6	3.41E-02	4.14E-05	1.11E+00	8.08E-07	5.65E-08	1.42E-04	1.50E-08	4.02E-02	1.54E-04	4.19E-06	1.18E+00	1.85E-01	0.00E+00	2.47E-08	3.35E-02	0.00E+00	6.18E-04	0.00E+00	3.70E-05	7.02E-02	5.85E-08	1.10E-01	3.65E-03	1.51E-03	9.28E-03	1.00E-06	4.78E-07	4.78E-07	2.79E-03	3.72E-04	4.58E-04	2.01E+01	8.34E-03	4.97E-07	1.00E-07	1.02E-04	1.44E-05	3.93E-07	1.48E-06	4.59E-06	2.01E+01
30	100	88.6	7.14E-02	9.02E-05	4.40E+00	1.45E-06	2.73E-01	1.04E-03	5.23E-08	1.86E+00	2.47E-01	9.76E-06	4.05E+00	2.92E+00	0.00E+00	5.11E-08	2.63E+00	0.00E+00	1.58E-03	0.00E+00	1.53E-06	3.25E-01	2.73E-01	8.55E+00	5.66E-02	4.06E-02	4.32E+00	9.74E-06	1.28E-01	1.28E-01	1.04E+00	8.71E-04	7.97E-04	8.70E+01	1.48E-02	0.00E+00	0.00E+00	0.00E+00	3.38E-06	8.01E-07	8.24E-06	2.23E-06	8.70E+01
31	100	88.6	3.41E-02	4.14E-05	1.11E+00	8.08E-07	5.65E-08	1.42E-04	1.50E-08	4.02E-02	1.54E-04	4.19E-06	1.18E+00	1.85E-01	0.00E+00	2.47E-08	3.35E-02	0.00E+00	6.18E-04	0.00E+00	3.70E-05	7.02E-02	5.85E-08	1.10E-01	3.65E-03	1.51E-03	9.28E-03	1.00E-06	4.78E-07	4.78E-07	2.79E-03	3.72E-04	4.58E-04	2.01E+01	8.34E-03	4.97E-07	1.00E-07	1.02E-04	1.44E-05	3.93E-07	1.48E-06	4.59E-06	2.01E+01
32	100	88.6	7.81E-02	9.55E-05	3.93E+00	1.60E-06	7.10E-02	8.12E-04	5.62E-08	7.15E-01	5.14E-02	1.09E-05	4.15E+00	1.62E+00	0.00E+00	5.69E-08	1.03E+00	0.00E+00	1.76E-03	0.00E+00	7.46E-06	7.52E+00	7.10E-02	2.47E+00	2.29E-02	1.70E-02	8.96E-01	3.59E-06	2.85E-02	2.85E-02	2.46E-01	9.70E-04	8.88E-04	7.66E+01	1.64E-02	0.00E+00	0.00E+00	0.00E+00	1.80E-06	2.58E-07	4.05E-06	1.21E-07	7.66E+01
33	100	88.6	1.61E-01	2.49E-04	8.68E+00	0.00E+00	2.27E+00	1.13E-04	3.74E-11	1.30E+00	5.20E-02	1.51E-05	7.06E+00	1.07E+00	0.00E+00	1.09E-07	5.23E-02	0.00E+00	1.84E-03	0.00E+00	1.17E-04	7.78E+01	2.27E+00	0.00E+00	1.89E-02	3.75E-03	8.04E-02	7.79E-07	1.66E+00	1.66E+00	4.03E+00	1.32E-03	2.45E-03	1.04E+02	2.28E-02	0.00E+00	1.37E-08	0.00E+00	0.00E+00	1.55E-06	0.00E+00	1.41E-04	1.04E+02
34	100	88.6	2.21E-01	3.03E-04	7.95E+00	0.00E+00	1.09E+00	1.32E-04	4.58E-11	1.42E+00	5.28E-02	1.85E-05	8.41E+00	1.21E+00	0.00E+00	1.33E-07	5.19E-02	0.00E+00	2.25E-03	0.00E+00	8.17E-05	8.03E+01	1.09E+00	0.00E+00	1.71E-02	3.82E-03	7.92E-02	7.92E-07	1.28E+00	1.28E+00	4.17E+00	1.61E-03	3.00E-03	1.24E+02	2.79E-02	0.00E+00	1.66E-08	0.00E+00	0.00E+00	1.50E-06	0.00E+00	1.06E-04	1.24E+02
35	100	88.6	9.67E-02	1.20E-04	6.24E+00	1.98E-06	2.25E-01	1.14E-03	7.16E-08	1.24E+00	9.28E-02	1.34E-05	8.94E+00	2.55E+00	0.00E+00	8.99E-08	1.59E+00	0.00E+00	2.17E-03	0.00E+00	9.36E-06	1.38E+01	2.25E-01	3.72E+00	3.14E-02	2.40E-02	1.49E+00	5.40E-06	6.55E-02	6.55E-02	4.51E-01	1.19E-03	1.09E-03	1.03E+02	2.02E-02	0.00E+00	0.00E+00	0.00E+00	2.59E-05	4.51E-07	7.66E-06	2.66E-07	1.03E+02
36	100	88.6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.48E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-05	0.00E+00	0.00E+00	3.68E+00	3.03E-02	2.40E-02	1.12E+00	5.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.48E-06	8.69E-07	1.56E-05	2.84E-07	0.00E+00
37	100	88.6	3.41E-02	4.14E-05	1.11E+00	8.08E-07	5.65E-08	1.42E-04	1.50E-08	4.02E-02	1.54E-04	4.19E-06	1.18E+00	1.85E-01	0.00E+00	2.47E-08	3.35E-02	0.00E+00	6.18E-04	0.00E+00	3.70E-05	7.02E-02	5.85E-08	1.10E-01	3.65E-03	1.51E-03	9.28E-03	1.00E-06	4.78E-07	4.78E-07	2.79E-03	3.72E-04	4.58E-04	2.01E+01	8.34E-03	4.97E-07	1.00E-07	1.02E-04	1.44E-05	3.93E-07	1.48E-06	4.59E-06	2.01E+01
38	100	88.6	1.39E-02	1.74E-05	1.18E+00	0.00E+00	6.95E-01	2.78E-04	1.43E-08	3.81E-01	7.92E-02	2.88E-06	1.25E+00	7.66E-01	0.00E+00	1.40E-08	1.03E-01	0.00E+00	3.07E-04	0.00E+00	2.28E-05	9.29E+00	6.95E-01	2.86E-01	2.23E-03	1.47E-03	1.05E-01	2.67E-06	1.23E-01	1.23E-01	2.93E-01	2.39E-04	2.18E-04	2.34E+01	4.33E-03	0.00E+00	0.00E+00	0.00E+00	4.43E-05	6.27E-07	1.03E-05	4.80E-08	2.34E+01
39	100	88.6	1.00E-01	1.26E-04	5.96E+00	2.04E-06	9.12E-01	1.38E-03	7.38E-08	2.12E+00	2.38E-01	1.38E-05	8.30E+00	3.62E+00	0.00E+00	7.21E-08	2.76E+00	0.00E+00	2.24E-03	0.00E+00	1.55E-05	3.25E+01	9.12E-01	5.97E+00	5.75E-02	3.99E-02	3.66E+00	9.97E-06	1.89E-01	1.89E-01	1.05E+00	1.23E-03	1.13E-03	1.18E+02	2.98E-02	0.00E+00	0.00E+00	0.00E+00	3.88E-05	5.69E-07	9.17E-06	4.32E-08	1.18E+02
40	100	88.6	8.28E-04	1.01E-06	9.02E-02	1.90E-08	3.91E-06	1.25E-05	8.66E-10	8.35E-03	2.11E-04	2.67E-07	9.54E-02	2.53E-02	0.00E+00	1.61E-09	2.04E-02	0.00E+00	1.30E-04	0.00E+00	2.05E-06	6.28E-02	3.91E-06	1.29E-02	6.50E-03	1.65E-03	9.63E-03	1.93E-06	9.02E-06	9.02E-06	2.51E-03	2.37E-05	3.04E-05	1.63E+00	4.04E-04	0.00E+00	2.79E-08	9.37E-06	3.37E-06	2.84E-07	5.55E-07	1.06E-05	1.63E+00
41	100	88.6	4.63E-03	5.76E-06	3.64E-01	0.00E+00	4.63E-04	8.08E-05	4.80E-09	7.42E-02	5.01E-03	8.96E-07	3.85E-01	1.89E-01	0.00E+00	4.69E-09	0.00E+00	0.00E+00	1.03E-04	0.00E+00	1.72E-05	9.09E-01	4.63E-04	9.15E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.53E-04	5.53E-04	3.05E-02	6.01E-05	7.33E-05	7.19E+00	1.36E-03	0.00E+00	0.00E+00	0.00E+00	5.77E-06	6.67E-08	1.66E-06	4.67E-09	7.19E+00
42	100	88.6	2.78E-02	3.28E-05	1.18E+00	1.57E-06	1.26E-05	2.02E-04	2.15E-08	6.48E-02	6.20E-04	4.07E-06	1.23E+00	2.66E-01	0.00E+00	2.14E-08	4.72E-02	0.00E+00	6.97E-04	0.00E+00	1.13E-05	1.86E-01	1.26E-06	1.38E-01	6.36E-03	2.27E-03	1.57E-02	2.09E-06	2.31E-05	2.31E-05	6.92E-03	3.63E-04	3.37E-04	2.23E+01	6.15E-03	2.85E-08	1.49E-08	3.73E-05	1.37E-05	3.24E-07	1.84E-06	5.68E-06	2.23E+01
43	100	88.6	1.39E-02	1.74E-05	1.18E+00	0.00E+00	6.95E-01	2.78E-04	1.43E-08	3.21E-01	7.92E-02	2.88E-06	1.25E+00	7.66E-01	0.00E+00	1.40E-08	1.03E-01	0.00E+00	3.07E-04	0.00E+00	2.28E-05	9.29E+00	6.95E-01	2.86E-01	2.23E-03	1.47E-03	1.05E-01	2.67E-06	1.23E-01	1.23E-01	2.93E-01	2.39E-04	2.18E-04	2.34E+01	4.03E-03	0.00E+00	0.00E+00	0.00E+00	4.43E-05	6.27E-07	1.03E-05	4.80E-08	2.34E+01
44	1000	886.0	0.00E+00	0.00E+00	9.95E-02	4.01E-06	5.14E-02	1.66E-06	5.58E-13	2.09E-02	1.02E-03	2.23E-07	1.05E-01	1.65E-02	0.00E+00	1.60E-09	4.86E-02	0.00E+00	2.35E-04	0.00E+00	0.00E+00	1.42E+00	5.14E-02	0.00E+00	1.81E-02	3.60E-03	8.18E-02	7.41E-07	4.05E-02	4.05E-02	7.25E-02	1.95E-05	3.61E-05	1.55E+00	3.37E-04	0.00E+00	7.00E-08	0.00E+00	0.00E+00	1.49E-07	0.00E+00	1.36E-05	1.55E+00
45	1000	886.0	0.00E+00	0.00E+00	9.95E-02	4.01E-06	5.14E-02	1.66E-06	5.58E-13	2.09E-02	1.02E-03	2.23E-07	1.05E-01	1.65E-02	0.00E+00	1.60E-09	4.86E-02	0.00E+00	2.35E-04	0.00E+00	0.00E+00	1.42E+00	5.14E-02	0.00E+00	1.81E-02	3.60E-03	8.18E-02	7.41E-07	4.05E-02	4.05E-02	7.25E-02	1.95E-05	3.61E-05	1.55E+00	3.37E-04	0.00E+00	7.00E-08	0.00E+00	0.00E+00	1.49E-07	0.00E+00	1.36E-05	1.55E+00
46	1000	886.0	0.00E+00	0.00E+00	9.95E-02	4.01E-06	5.14E-02	1.66E-06	5.58E-13	2.09E-02	1.02E-03	2.23E-07	1.05E-01	1.65E-02	0.00E+00	1.60E-09	4.86E-02	0.00E+00	2.35E-04	0.00E+00	0.00E+00	1.42E+00	5.14E-02	0.00E+00	1.81E-02	3.60E-03	8.18E-02	7.41E-07	4.05E-02	4.05E-02	7.25E-02	1.95E-05	3.61E-05	1.55E+00	3.37E-04	0.00E+00	7.00E-08	0.00E+00	0.00E+00	1.49E-07	0.00E+00	1.36E-05	1.55E+00
47	1000	886.0	0.00E+00	0.00E+00	7.92E-02	3.33E-06	1.40E-03	1.29E-06	4.64E-13	1.30E-02	3.43E-04	1.85E-07	8.37E-02	1.17E-02	0.00E+00	1.33E-09	5.42E-02	0.00E+00	1.96E-04	0.00E+00	0.00E+00	8.05E-01	1.40E-03	0.00E+00	1.73E-02	3.85E-03	7.01E-02	7.94E-07	3.25E-03	3.25E-03	3.20E-02	1.62E-05	3.01E-05	1.23E+00	2.81E-04	0.00E+00	5.71E-08	0.00E+00	0.00E+00	1.13E-07	0.00E+00	1.13E-05	1.23E+00
48	100	88.6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49	100	88.6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	1000	886.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51	100	88.6	6.04E-04	7.36E-07	7.47E-02	1.96E-08	4.75E-06	9.10E-06	6.20E-10	8.84E-03	1.65E-04	2.25E-07	7.90E-02	1.91E-02	0.00E+00	1.39E-09	2.13E-02	0.00E+00	1.29E-04	0.00E+00	1.41E-08	5.49E-02	4.75E-06	1.09E-02	6.72E-03	1.71E-03	1.00E-02	2.00E-06	9.78E-06	9.78E-06	2.23E-03	1.99E-05	2.71E-05	1.32E+00	3.40E-04	5.22E-11	2.88E-08	3.63E-06	2.31E-06	2.52E-07	4.43E-07	1.09E-05	1.32E+00

The density of the sludge remaining in the tanks is assumed to be equal to 0.886 kg/gal

F- and H-Area High Level Tank Farm Radionuclide Inventory

Radioactive Constituents Remaining in Each Tank (Note: Total Curies for each constituent is increased by 20% to account for piping and other ancillary equipment)

Tank	Am-241 (Ci)	Am-242m (Ci)	Ba-137m (Ci)	C-14 (Ci)	Ce-144 (Ci)	Cm-244 (Ci)	Cm-248 (Ci)	Co-60 (Ci)	Cs-134 (Ci)	Cs-135 (Ci)	Cs-137 (Ci)	Eu-154 (Ci)
1	1.81E+01	2.05E-02	3.60E+02	1.55E-04	1.08E-07	4.23E-03	3.48E-09	5.81E+00	2.05E-03	1.41E-03	3.80E+02	1.56E+01
2	1.01E+01	1.26E-02	1.99E+02	2.89E-04	3.25E-11	2.12E-03	2.22E-09	1.45E+00	9.99E-05	8.99E-04	2.11E+02	5.94E+00
3	4.47E+00	5.61E-03	9.22E+01	1.28E-04	2.78E-10	1.01E-03	9.85E-10	8.41E-01	9.98E-05	3.98E-04	9.74E+01	3.08E+00
4	1.77E+01	2.31E-02	4.70E+02	7.97E-08	1.64E-02	6.35E-03	3.76E-09	2.40E+01	1.42E-01	1.52E-03	4.97E+02	3.57E+01
5	1.34E+01	1.73E-02	3.22E+02	1.28E-04	1.62E-06	3.99E-03	2.84E-09	7.33E+00	5.62E-03	1.17E-03	3.41E+02	1.70E+01
6	2.61E+01	3.39E-02	6.58E+02	0.00E+00	3.32E-05	8.48E-03	5.58E-09	1.89E+01	2.23E-02	2.25E-03	6.96E+02	3.93E+01
7	2.31E+00	2.92E-03	5.30E+01	2.42E-04	1.38E-08	6.09E-04	5.31E-10	7.22E-01	2.36E-04	2.14E-04	5.60E+01	2.14E+00
8	4.88E+00	6.39E-03	1.34E+02	2.01E-04	5.68E-04	1.79E-03	1.06E-09	5.49E+00	1.41E-02	4.30E-04	1.41E+02	9.48E+00
9	1.13E+01	1.41E-02	2.24E+02	3.25E-04	3.56E-11	2.38E-03	2.50E-09	1.62E+00	1.11E-04	1.01E-03	2.37E+02	6.66E+00
10	5.57E+00	6.95E-03	1.14E+02	1.59E-04	5.46E-11	1.84E-03	9.65E-08	9.49E-01	1.15E-04	5.04E-04	1.20E+02	4.01E+00
11	6.60E+00	7.94E-03	2.98E+02	1.46E-04	4.26E-03	5.55E-02	5.00E-06	2.70E+01	3.18E-01	9.34E-04	3.15E+02	8.67E+01
12	7.74E+00	9.25E-03	3.07E+02	1.67E-04	2.60E-05	5.28E-02	5.26E-06	1.82E+01	8.22E-02	1.05E-03	3.25E+02	7.22E+01
13	3.62E+00	4.40E-03	1.18E+02	8.59E-05	6.22E-06	1.51E-02	1.59E-08	4.28E+00	1.63E-02	4.48E-04	1.25E+02	1.97E+01
14	1.62E+01	2.02E-02	3.66E+02	3.85E-06	7.52E-09	1.49E-02	1.56E-06	4.74E+00	1.99E-03	1.53E-03	3.87E+02	2.18E+01
15	7.94E+00	9.36E-03	3.18E+02	1.64E-04	1.90E-04	5.49E-02	6.04E-06	1.57E+01	5.86E-02	1.13E-03	3.34E+02	8.85E+01
16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	0.00E+00	0.00E+00	6.62E+01	3.80E-03	1.69E-04	8.85E-04	5.29E-10	2.86E+00	6.25E-03	2.11E-04	7.00E+01	4.80E+00
18	0.00E+00	0.00E+00	3.77E+01	2.25E-03	9.76E-06	4.93E-04	3.14E-10	1.47E+00	4.25E-03	1.25E-04	3.99E+01	2.56E+00
19	0.00E+00	0.00E+00	1.66E+01	8.75E-04	2.72E-06	2.32E-04	1.22E-10	9.11E-01	2.84E-03	4.67E-05	1.75E+01	1.40E+00
20	0.00E+00	0.00E+00	1.66E+01	8.75E-04	2.72E-06	2.32E-04	1.22E-10	9.11E-01	2.84E-03	4.67E-05	1.75E+01	1.40E+00
21	6.45E-01	1.03E-03	5.82E+01	1.65E-06	7.64E-03	1.21E-02	6.60E-07	7.68E+00	2.72E-01	1.90E-04	6.15E+01	2.37E+01
22	8.43E-01	1.03E-03	5.96E+01	0.00E+00	3.89E-03	1.23E-02	8.61E-07	7.25E+00	2.11E-01	1.64E-04	6.29E+01	2.35E+01
23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	3.62E+00	4.40E-03	1.18E+02	8.59E-05	6.22E-06	1.51E-02	1.59E-08	4.28E+00	1.63E-02	4.48E-04	1.25E+02	1.97E+01
25	0.00E+00	0.00E+00	1.06E+02	4.26E-03	5.47E+01	1.78E-03	5.93E-10	2.23E+01	1.08E+00	2.37E-04	1.12E+02	1.78E+01
26	0.00E+00	0.00E+00	1.06E+02	4.26E-03	5.47E+01	1.78E-03	5.93E-10	2.23E+01	1.08E+00	2.37E-04	1.12E+02	1.78E+01
27	0.00E+00	0.00E+00	1.06E+02	4.26E-03	5.47E+01	1.78E-03	5.93E-10	2.23E+01	1.08E+00	2.37E-04	1.12E+02	1.78E+01
28	0.00E+00	0.00E+00	1.06E+02	4.26E-03	5.47E+01	1.78E-03	5.93E-10	2.23E+01	1.08E+00	2.37E-04	1.12E+02	1.78E+01
29	3.62E+00	4.40E-03	1.18E+02	8.59E-05	6.22E-06	1.51E-02	1.59E-08	4.28E+00	1.63E-02	4.48E-04	1.25E+02	1.97E+01
30	7.59E+00	9.59E-03	4.87E+02	1.54E-04	2.91E+01	1.11E-01	5.56E-08	1.96E+02	2.63E+01	1.04E-03	4.94E+02	3.10E+02
31	3.62E+00	4.40E-03	1.18E+02	8.59E-05	6.22E-06	1.51E-02	1.59E-08	4.28E+00	1.63E-02	4.48E-04	1.25E+02	1.97E+01
32	8.30E+00	1.02E-02	4.18E+02	1.70E-04	7.54E+00	8.83E-02	6.19E-08	7.60E+01	5.47E+00	1.18E-03	4.41E+02	1.72E+02
33	1.92E+01	2.65E-02	7.10E+02	0.00E+00	2.41E+02	1.20E-02	3.98E-09	1.38E+02	5.63E+00	1.61E-03	7.50E+02	1.14E+02
34	2.34E+01	3.22E-02	8.45E+02	0.00E+00	1.16E+02	1.40E-02	4.87E-09	1.51E+02	5.82E+00	1.98E-03	8.94E+02	1.29E+02
35	1.03E+01	1.27E-02	5.57E+02	2.10E-04	2.39E+01	1.21E-01	7.61E-08	1.32E+02	9.87E+00	1.42E-03	5.89E+02	2.71E+02
36	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37	3.62E+00	4.40E-03	1.18E+02	8.59E-05	6.22E-06	1.51E-02	1.59E-08	4.28E+00	1.63E-02	4.48E-04	1.25E+02	1.97E+01
38	1.47E+00	1.86E-03	1.25E+02	0.00E+00	7.39E+01	2.96E-02	1.52E-08	4.05E+01	6.42E+00	2.83E-04	1.33E+02	8.14E+01
39	1.07E+01	1.34E-02	6.34E+02	2.17E-04	9.70E+01	1.47E-01	7.85E-08	2.25E+02	2.53E+01	1.46E-03	6.70E+02	3.85E+02
40	8.80E-02	1.08E-04	9.59E+00	2.02E-04	4.15E-04	1.32E-03	9.20E-08	8.89E-01	2.24E-02	2.84E-05	1.01E+01	2.89E+00
41	4.92E-01	6.12E-04	3.87E+01	0.00E+00	4.92E-02	8.60E-03	5.11E-07	7.89E+00	5.32E-01	9.52E-06	4.09E+01	2.00E+01
42	2.96E+00	3.49E-03	1.23E+02	1.67E-04	1.34E-03	2.15E-02	2.28E-06	6.89E+00	6.59E-02	4.32E-04	1.30E+02	2.63E+01
43	1.47E+00	1.86E-03	1.25E+02	0.00E+00	7.39E+01	2.96E-02	1.52E-08	4.05E+01	6.42E+00	2.83E-04	1.33E+02	8.14E+01
44	0.00E+00	0.00E+00	1.06E+02	4.26E-03	5.47E+01	1.78E-03	5.93E-10	2.23E+01	1.08E+00	2.37E-04	1.12E+02	1.78E+01
45	0.00E+00	0.00E+00	1.06E+02	4.26E-03	5.47E+01	1.78E-03	5.93E-10	2.23E+01	1.08E+00	2.37E-04	1.12E+02	1.78E+01
46	0.00E+00	0.00E+00	1.06E+02	4.26E-03	5.47E+01	1.78E-03	5.93E-10	2.23E+01	1.08E+00	2.37E-04	1.12E+02	1.78E+01
47	0.00E+00	0.00E+00	8.42E+01	3.54E-03	1.49E+00	1.37E-03	4.93E-10	1.36E+01	3.66E-01	1.97E-04	8.90E+01	1.24E+01
48	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51	6.42E-02	7.84E-05	7.94E+00	2.06E-04	5.05E-04	9.67E-04	8.59E-08	7.10E-01	1.97E-02	2.39E-05	8.40E+00	2.04E+00

Tank	H-3 (Ci)	I-129 (Ci)	IAm-241 (Ci)	Nb-94 (Ci)	Ni-59 (Ci)	Ni-63 (Ci)	Np-237 (Ci)	Pm-147 (Ci)	Pr-144 (Ci)	Pu-238 (Ci)	Pu-239 (Ci)	Pu-240 (Ci)	Pu-241 (Ci)	Pu-242 (Ci)
1	0.00E+00	1.01E-05	1.96E+00	0.00E+00	1.60E-01	0.00E+00	5.97E-03	1.61E+01	1.08E-07	0.00E+00	1.24E+00	2.76E-01	4.66E-01	5.70E-05
2	0.00E+00	8.48E-06	1.88E+00	0.00E+00	1.25E-01	0.00E+00	1.42E-02	1.43E+00	3.25E-11	0.00E+00	1.33E+00	2.96E-01	2.91E-01	6.11E-05
3	0.00E+00	2.87E-06	1.21E+00	0.00E+00	5.52E-02	0.00E+00	1.30E-02	1.17E+00	2.78E-10	0.00E+00	8.17E-01	1.82E-01	2.55E-01	3.76E-05
4	0.00E+00	1.09E-05	2.01E+00	0.00E+00	1.86E-01	0.00E+00	4.75E-03	4.09E+02	1.54E-02	0.00E+00	9.50E-01	2.12E-01	9.02E-01	4.37E-05
5	0.00E+00	6.39E-06	1.87E+00	0.00E+00	1.49E-01	0.00E+00	8.06E-03	3.39E+01	1.82E-06	0.00E+00	9.26E-01	2.21E-01	4.99E-01	6.53E-06
6	0.00E+00	1.82E-05	3.18E+00	0.00E+00	2.74E-01	0.00E+00	2.27E-03	1.14E+02	3.32E-05	0.00E+00	8.70E-01	2.32E-01	1.06E+00	4.59E-04
7	0.00E+00	1.54E-06	2.10E+00	0.00E+00	3.88E-02	0.00E+00	2.25E-03	1.89E+00	1.38E-08	0.00E+00	9.81E-01	2.34E-01	5.99E-01	7.56E-06
8	0.00E+00	3.09E-06	2.64E+00	0.00E+00	6.29E-02	0.00E+00	1.90E-03	5.47E+01	5.68E-04	0.00E+00	1.19E+00	2.79E-01	1.74E+00	3.56E-04
9	0.00E+00	7.27E-06	5.46E-01	0.00E+00	1.40E-01	0.00E+00	1.41E-02	1.60E+00	3.56E-11	0.00E+00	4.36E-01	9.72E-02	9.44E-02	2.01E-05
10	0.00E+00	3.59E-06	1.38E+00	0.00E+00	7.03E-02	0.00E+00	1.43E-02	9.66E-01	5.46E-11	0.00E+00	1.04E+00	2.31E-01	2.52E-01	4.76E-05
11	0.00E+00	4.89E-06	5.20E+01	0.00E+00	1.51E-01	0.00E+00	1.02E-03	9.30E+01	4.26E-03	1.26E+02	1.37E+00	8.56E-01	2.85E+01	1.83E-03
12	0.00E+00	5.63E-06	2.30E+01	0.00E+00	1.69E-01	0.00E+00	5.00E-03	3.46E+01	2.60E-05	7.84E+01	1.48E+00	8.04E-01	1.02E+01	1.16E-03
13	0.00E+00	2.63E-06	3.56E+00	0.00E+00	8.57E-02	0.00E+00	3.93E-03	7.47E+00	6.22E-06	1.17E+01	3.88E-01	1.60E-01	9.87E-01	1.07E-04
14	0.00E+00	1.06E-05	3.28E+00	0.00E+00	1.97E-01	0.00E+00	1.40E-02	5.40E+00	7.52E-09	5.17E+00	1.54E+00	4.97E-01	7.51E-01	9.14E-05
15	0.00E+00	5.90E-06	1.07E+01	0.00E+00	1.82E-01	0.00E+00	2.49E-03	2.55E+01	1.99E-04	3.40E+01	8.52E-01	4.11E-01	3.05E+00	3.11E-04
16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	0.00E+00	1.52E-06	4.74E+01	0.00E+00	2.23E-01	0.00E+00	0.00E+00	3.08E+01	1.69E-04	0.00E+00	1.33E+01	3.50E+00	2.34E+01	5.06E-03
18	0.00E+00	9.02E-07	2.43E+01	0.00E+00	1.32E-01	0.00E+00	0.00E+00	1.56E+01	9.76E-05	0.00E+00	7.72E+00	1.96E+00	1.14E+01	2.29E-03
19	0.00E+00	3.50E-07	0.00E+00	0.00E+00	5.15E-02	0.00E+00	0.00E+00	1.07E+01	2.72E-05	0.00E+00	4.58E+00	1.02E+00	1.95E+02	2.10E-03
20	0.00E+00	3.50E-07	0.00E+00	0.00E+00	5.15E-02	0.00E+00	0.00E+00	1.07E+01	2.72E-05	0.00E+00	4.58E+00	1.02E+00	1.95E+02	2.10E-03
21	0.00E+00	8.41E-07	3.93E-01	0.00E+00	1.90E-02	0.00E+00	1.93E-03	6.07E+01	7.64E-03	1.61E+01	2.01E-02	1.16E-02	2.29E-01	9.78E-06
22	0.00E+00	8.61E-07	0.00E+00	0.00E+00	1.89E-02	0.00E+00	2.06E-03	5.06E+01	3.89E-03	1.32E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	0.00E+00	2.63E-06	3.56E+00	0.00E+00	6.57E-02	0.00E+00	3.93E-03	7.47E+00	6.22E-06	1.17E+01	3.88E-01	1.60E-01	9.87E-01	1.07E-04
25	0.00E+00	1.70E-06	5.16E+01	0.00E+00	2.50E-01	0.00E+00	0.00E+00	1.51E+03	5.47E+01	0.00E+00	1.71E+01	3.83E+00	8.69E+01	7.88E-04
26	0.00E+00	1.70E-06	5.16E+01	0.00E+00	2.50E-01	0.00E+00	0.00E+00	1.51E+03	5.47E+01	0.00E+00	1.71E+01	3.83E+00	8.69E+01	7.88E-04
27	0.00E+00	1.70E-06	5.16E+01	0.00E+00	2.50E-01	0.00E+00	0.00E+00	1.51E+03	5.47E+01	0.00E+00	1.71E+01	3.83E+00	8.69E+01	7.88E-04
28	0.00E+00	1.70E-06	5.16E+01	0.00E+00	2.50E-01	0.00E+00	0.00E+00	1.51E+03	5.47E+01	0.00E+00	1.71E+01	3.83E+00	8.69E+01	7.88E-04
29	0.00E+00	2.63E-06	3.56E+00	0.00E+00	6.57E-02	0.00E+00	3.93E-03	7.47E+00	6.22E-06	1.17E+01	3.88E-01	1.60E-01	9.87E-01	1.07E-04
30	0.00E+00	5.43E-06	2.80E+02	0.00E+00	1.66E-01	0.00E+00	1.62E-03	3.46E+03	2.91E+01	6.97E+02	6.02E+00	4.32E+00	4.60E+02	1.04E-02
31	0.00E+00	2.63E-06	3.56E+00	0.00E+00	6.57E-02	0.00E+00	3.93E-03	7.47E+00	6.22E-06	1.17E+01	3.88E-01	1.60E-01	9.87E-01	1.07E-04
32	0.00E+00	8.05E-06	1.09E+02	0.00E+00	1.87E-01	0.00E+00	7.93E-04	7.99E+02	7.54E+00	2.63E+02	2.44E+00	1.81E+00	9.52E+01	3.82E-03
33	0.00E+00	1.16E-06	5.56E+00	0.00E+00	1.96E-01	0.00E+00	1.24E-02	8.27E+03	2.41E+02	0.00E+00	1.80E+00	4.02E-01	6.54E+00	6.28E-06
34	0.00E+00	1.41E-06	5.52E+00	0.00E+00	2.40E-01	0.00E+00	8.69E-03	8.54E+03	1.16E+02	0.00E+00	1.62E+00	4.06E-01	8.42E+00	8.42E-06
35	0.00E+00	7.43E-06	1.89E+02	0.00E+00	2.30E-01	0.00E+00	9.97E-04	1.46E+03	2.39E+01	3.96E+02	3.34E+00	2.55E+00	1.59E+02	5.74E-03
36	0.00E+00	0.00E+00	1.57E+02	0.00E+00	0.00E+00	0.00E+00	1.33E-03	0.00E+00	0.00E+00	3.91E+02	3.22E+00	2.56E+00	1.19E+02	5.53E-03
37	0.00E+00	2.63E-06	3.56E+00	0.00E+00	6.57E-02	0.00E+00	3.93E-03	7.47E+00	6.22E-06	1.17E+01	3.88E-01	1.60E-01	9.87E-01	1.07E-04
38	0.00E+00	1.49E-06	1.09E+01	0.00E+00	3.27E-02	0.00E+00	2.40E-03	9.87E+02	7.39E+01	3.06E+01	2.37E-01	1.57E-01	1.12E+01	2.84E-04
39	0.00E+00	7.66E-06	2.94E+02	0.00E+00	2.38E-01	0.00E+00	1.85E-03	3.45E+03	9.70E+01	6.35E+02	8.11E+00	4.24E+00	3.89E+02	1.06E-02
40	0.00E+00	1.71E-07	2.17E+00	0.00E+00	1.38E-02	0.00E+00	2.16E-04	6.66E+00	4.15E-04	1.38E+00	6.91E-01	1.75E-01	1.02E+00	2.05E-04
41	0.00E+00	4.99E-07	0.00E+00	0.00E+00	1.10E-02	0.00E+00	1.83E-03	9.67E+01	4.92E-02	9.72E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
42	0.00E+00	2.27E-06	5.02E+00	0.00E+00	7.41E-02	0.00E+00	1.20E-03	1.98E+01	1.34E-03	1.47E+01	6.76E-01	2.42E-01	1.67E+00	2.22E-04
43	0.00E+00	1.49E-06	1.09E+01	0.00E+00	3.27E-02	0.00E+00	2.40E-03	9.87E+02	7.39E+01	3.06E+01	2.37E-01	1.57E-01	1.12E+01	2.84E-04
44	0.00E+00	1.70E-06	5.16E+01	0.00E+00	2.50E-01	0.00E+00	0.00E+00	1.51E+03	5.47E+01	0.00E+00	1.71E+01	3.83E+00	8.69E+01	7.88E-04
45	0.00E+00	1.70E-06	5.16E+01	0.00E+00	2.50E-01	0.00E+00	0.00E+00	1.51E+03	5.47E+01	0.00E+00	1.71E+01	3.83E+00	8.69E+01	7.88E-04
46	0.00E+00	1.70E-06	5.16E+01	0.00E+00	2.50E-01	0.00E+00	0.00E+00	1.51E+03	5.47E+01	0.00E+00	1.71E+01	3.83E+00	8.69E+01	7.88E-04
47	0.00E+00	1.42E-06	5.76E+01	0.00E+00	2.08E-01	0.00E+00	0.00E+00	6.43E+02	1.49E+00	0.00E+00	1.64E+01	4.10E+00	7.45E+01	6.44E-04
48	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51	0.00E+00	1.48E-07	2.26E+00	0.00E+00	1.37E-02	0.00E+00	1.50E-04	5.83E+00	5.05E-04	1.16E+00	7.14E-01	1.82E-01	1.07E+00	2.12E-04

Tank	Rh-106 (Ci)	Ru-106 (Ci)	Sb-125 (Ci)	Se-79 (Ci)	Sn-126 (Ci)	Sr-90 (Ci)	Tc-99 (Ci)	Th-232 (Ci)	U-232 (Ci)	U-233 (Ci)	U-234 (Ci)	U-235 (Ci)	U-236 (Ci)	U-238 (Ci)	Y-90 (Ci)
1	1.70E-05	1.70E-05	1.05E+00	1.23E-01	2.28E-01	5.44E+03	2.12E+00	0.00E+00	1.02E-04	0.00E+00	0.00E+00	1.85E-04	0.00E+00	4.09E-03	5.44E+03
2	3.79E-08	3.79E-08	1.03E-01	7.86E-02	1.46E-01	2.99E+03	1.36E+00	0.00E+00	6.31E-05	0.00E+00	0.00E+00	5.46E-05	0.00E+00	1.36E-03	2.99E+03
3	1.30E-07	1.30E-07	8.10E-02	3.48E-02	6.47E-02	1.39E+03	6.02E-01	0.00E+00	2.85E-05	0.00E+00	0.00E+00	6.98E-05	0.00E+00	1.74E-03	1.39E+03
4	1.39E-01	1.39E-01	2.33E+01	1.33E-01	2.47E-01	7.19E+03	2.29E+00	0.00E+00	1.18E-04	0.00E+00	0.00E+00	1.24E-04	0.00E+00	5.32E-03	7.19E+03
5	1.52E-04	1.52E-04	2.14E+00	1.02E-01	1.89E-01	4.90E+03	1.76E+00	0.00E+00	8.74E-05	0.00E+00	0.00E+00	2.01E-04	0.00E+00	4.77E-03	4.90E+03
6	1.50E-03	1.50E-03	7.08E+00	1.98E-01	3.68E-01	1.00E+04	3.40E+00	0.00E+00	1.71E-04	0.00E+00	0.00E+00	1.75E-04	0.00E+00	6.56E-03	1.00E+04
7	2.02E-06	2.02E-06	1.24E-01	1.87E-02	3.49E-02	8.00E+02	3.24E-01	0.00E+00	1.75E-06	0.00E+00	0.00E+00	1.02E-04	0.00E+00	2.45E-03	8.00E+02
8	5.49E-03	5.49E-03	3.25E+00	3.75E-02	6.98E-02	2.04E+03	8.49E-01	0.00E+00	3.56E-05	0.00E+00	0.00E+00	8.96E-05	0.00E+00	4.15E-03	2.04E+03
9	4.17E-06	4.17E-06	1.14E-01	8.83E-02	1.64E-01	3.35E+03	1.53E+00	0.00E+00	7.08E-05	0.00E+00	0.00E+00	8.26E-05	0.00E+00	2.06E-03	3.35E+03
10	3.90E-08	3.90E-08	6.67E-02	4.40E-02	8.04E-02	1.72E+03	7.61E-01	0.00E+00	3.43E-05	0.00E+00	0.00E+00	7.51E-05	0.00E+00	1.67E-03	1.72E+03
11	7.78E-03	7.78E-03	3.35E+00	8.34E-02	7.63E-02	5.78E+03	1.41E+00	1.32E-05	1.60E-07	1.68E-03	1.54E-03	2.91E-05	2.39E-04	5.40E-05	5.78E+03
12	2.39E-04	2.39E-04	1.32E+00	9.36E-02	9.12E-02	5.87E+03	1.59E+00	8.57E-04	4.80E-06	2.41E-02	2.26E-03	4.25E-05	1.79E-04	4.26E-04	5.87E+03
13	5.08E-05	5.08E-05	2.97E-01	3.96E-02	4.64E-02	2.14E+03	6.74E-01	5.29E-05	1.06E-05	1.08E-02	1.53E-03	4.18E-05	1.58E-04	4.88E-04	2.14E+03
14	6.65E-07	6.65E-07	3.40E-01	1.35E-01	2.25E-01	5.81E+03	2.32E+00	2.71E-04	6.59E-05	9.56E-03	1.31E-03	1.06E-04	1.13E-04	2.02E-03	5.81E+03
15	4.25E-04	4.25E-04	9.72E-01	1.01E-01	9.22E-02	6.08E+03	1.71E+00	7.98E-04	0.00E+00	9.71E-03	2.65E-03	4.28E-05	2.51E-04	9.82E-07	6.08E+03
16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	2.71E-03	2.71E-03	1.82E+00	1.85E-02	3.43E-02	1.01E+03	3.20E-01	0.00E+00	5.88E-06	0.00E+00	0.00E+00	3.66E-04	0.00E+00	2.27E-02	1.01E+03
18	1.52E-03	1.52E-03	9.21E-01	1.10E-02	2.04E-02	5.78E+02	1.90E-01	0.00E+00	3.31E-06	0.00E+00	0.00E+00	2.52E-04	0.00E+00	1.25E-02	5.78E+02
19	6.46E-04	6.46E-04	6.30E-01	4.26E-03	7.91E-03	2.55E+02	7.38E-02	0.00E+00	1.36E-06	0.00E+00	0.00E+00	6.54E-05	0.00E+00	7.80E-03	2.55E+02
20	6.46E-04	6.46E-04	6.30E-01	4.26E-03	7.91E-03	2.55E+02	7.38E-02	0.00E+00	1.36E-06	0.00E+00	0.00E+00	6.54E-05	0.00E+00	7.80E-03	2.55E+02
21	1.35E-02	1.35E-02	2.10E+00	1.43E-02	1.31E-02	1.14E+03	2.43E-01	1.04E-07	0.00E+00	3.18E-03	3.14E-03	4.33E-05	6.42E-04	2.93E-06	1.14E+03
22	7.87E-03	7.87E-03	1.76E+00	1.47E-02	1.34E-02	1.17E+03	2.49E-01	0.00E+00	0.00E+00	9.54E-03	3.43E-03	5.24E-06	5.64E-04	7.63E-06	1.17E+03
23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	5.08E-05	5.08E-05	2.97E-01	3.96E-02	4.64E-02	2.14E+03	6.74E-01	5.29E-05	1.06E-05	1.08E-02	1.53E-03	4.18E-05	1.58E-04	4.88E-04	2.14E+03
25	4.30E+01	4.30E+01	7.71E+01	2.07E-02	3.84E-02	1.65E+03	3.59E-01	0.00E+00	7.44E-05	0.00E+00	0.00E+00	1.58E-04	0.00E+00	1.45E-02	1.65E+03
26	4.30E+01	4.30E+01	7.71E+01	2.07E-02	3.84E-02	1.65E+03	3.59E-01	0.00E+00	7.44E-05	0.00E+00	0.00E+00	1.58E-04	0.00E+00	1.45E-02	1.65E+03
27	4.30E+01	4.30E+01	7.71E+01	2.07E-02	3.84E-02	1.65E+03	3.59E-01	0.00E+00	7.44E-05	0.00E+00	0.00E+00	1.58E-04	0.00E+00	1.45E-02	1.65E+03
28	4.30E+01	4.30E+01	7.71E+01	2.07E-02	3.84E-02	1.65E+03	3.59E-01	0.00E+00	7.44E-05	0.00E+00	0.00E+00	1.58E-04	0.00E+00	1.45E-02	1.65E+03
29	5.08E-05	5.08E-05	2.97E-01	3.96E-02	4.64E-02	2.14E+03	6.74E-01	5.29E-05	1.06E-05	1.08E-02	1.53E-03	4.18E-05	1.58E-04	4.88E-04	2.14E+03
30	1.38E+01	1.38E+01	1.11E+02	9.26E-02	8.48E-02	9.25E+03	1.57E+00	0.00E+00	0.00E+00	0.00E+00	3.60E-03	6.38E-05	6.64E-04	2.37E-06	9.25E+03
31	5.08E-05	5.08E-05	2.97E-01	3.96E-02	4.64E-02	2.14E+03	6.74E-01	5.29E-05	1.06E-05	1.08E-02	1.53E-03	4.18E-05	1.58E-04	4.88E-04	2.14E+03
32	3.03E+00	3.03E+00	2.61E+01	1.03E-01	9.44E-02	8.17E+03	1.75E+00	0.00E+00	0.00E+00	0.00E+00	1.92E-03	2.74E-05	4.30E-04	1.29E-06	8.17E+03
33	1.79E+02	1.79E+02	4.29E+02	1.40E-01	2.61E-01	1.11E+04	2.43E+00	0.00E+00	1.49E-04	0.00E+00	0.00E+00	1.65E-04	0.00E+00	1.50E-02	1.11E+04
34	1.36E+02	1.36E+02	4.44E+02	1.72E-01	3.19E-01	1.32E+04	2.97E+00	0.00E+00	1.76E-04	0.00E+00	0.00E+00	1.59E-04	0.00E+00	1.13E-02	1.32E+04
35	6.96E+00	6.96E+00	4.80E+01	1.27E-01	1.16E-01	1.09E+04	2.15E+00	0.00E+00	0.00E+00	0.00E+00	2.78E-03	4.79E-05	8.14E-04	2.83E-06	1.09E+04
36	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.77E-03	9.24E-05	1.88E-03	3.02E-06	0.00E+00
37	5.08E-05	5.08E-05	2.97E-01	3.96E-02	4.64E-02	2.14E+03	6.74E-01	5.29E-05	1.06E-05	1.08E-02	1.53E-03	4.18E-05	1.58E-04	4.88E-04	2.14E+03
38	1.31E+01	1.31E+01	3.12E+01	2.54E-02	2.32E-02	2.49E+03	4.29E-01	0.00E+00	0.00E+00	0.00E+00	4.71E-03	6.67E-05	1.10E-03	5.10E-06	2.49E+03
39	2.01E+01	2.01E+01	1.11E+02	1.31E-01	1.20E-01	1.25E+04	2.22E+00	0.00E+00	0.00E+00	0.00E+00	4.13E-03	6.05E-05	9.75E-04	4.59E-06	1.25E+04
40	9.59E-04	9.59E-04	2.87E-01	2.62E-03	3.23E-03	1.74E+02	4.30E-02	0.00E+00	2.96E-06	9.97E-04	3.58E-04	2.80E-05	5.90E-05	1.12E-03	1.74E+02
41	5.88E-02	5.88E-02	3.24E+00	8.52E-03	7.79E-03	7.64E+02	1.44E-01	0.00E+00	0.00E+00	0.00E+00	6.13E-04	7.09E-06	1.76E-04	4.66E-07	7.64E+02
42	2.45E-03	2.45E-03	7.36E-01	3.86E-02	3.58E-02	2.37E+03	6.54E-01	2.62E-04	1.59E-06	3.97E-03	1.46E-03	3.44E-05	1.95E-04	6.04E-04	2.37E+03
43	1.31E+01	1.31E+01	3.12E+01	2.54E-02	2.32E-02	2.49E+03	4.29E-01	0.00E+00	0.00E+00	0.00E+00	4.71E-03	6.67E-05	1.10E-03	5.10E-06	2.49E+03
44	4.30E+01	4.30E+01	7.71E+01	2.07E-02	3.84E-02	1.65E+03	3.59E-01	0.00E+00	7.44E-05	0.00E+00	0.00E+00	1.58E-04	0.00E+00	1.45E-02	1.65E+03
45	4.30E+01	4.30E+01	7.71E+01	2.07E-02	3.84E-02	1.65E+03	3.59E-01	0.00E+00	7.44E-05	0.00E+00	0.00E+00	1.58E-04	0.00E+00	1.45E-02	1.65E+03
46	4.30E+01	4.30E+01	7.71E+01	2.07E-02	3.84E-02	1.65E+03	3.59E-01	0.00E+00	7.44E-05	0.00E+00	0.00E+00	1.58E-04	0.00E+00	1.45E-02	1.65E+03
47	3.46E+00	3.46E+00	3.40E+01	1.72E-02	3.20E-02	1.31E+03	2.99E-01	0.00E+00	6.07E-05	0.00E+00	0.00E+00	1.21E-04	0.00E+00	1.20E-02	1.31E+03
48	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51	1.04E-03	1.04E-03	2.37E-01	2.11E-03	2.89E-03	1.41E+02	3.62E-02	5.55E-09	3.06E-06	3.86E-04	2.45E-04	2.64E-05	4.71E-05	1.16E-03	1.41E+02

F- and H-Area High Level Tank Farm Radionuclide Inventory

Radioactive Constituents Remaining in the Tank Groups

Tank Group	Am-241 (Ci)	Am-242m (Ci)	Ba-137m (Ci)	C-14 (Ci)	Ce-144 (Ci)	Cm-244 (Ci)	Cm-248 (Ci)	Co-60 (Ci)	Cs-134 (Ci)	Cs-135 (Ci)	Cs-137 (Ci)	Eu-154 (Ci)	H-3 (Ci)	I-129 (Ci)	IAm-241 (Ci)	Nb-94 (Ci)	Ni-59 (Ci)	Ni-63 (Ci)	Np-237 (Ci)	Pm-147 (Ci)
1 thru 8	9.51E+01	1.22E-01	2.29E+03	1.15E-03	1.60E-02	2.66E-02	2.05E-08	6.44E+01	1.67E-01	8.28E-03	2.42E+03	1.28E+02	0.00E+00	5.98E-05	1.68E+01	0.00E+00	1.07E+00	0.00E+00	5.25E-02	6.32E+02
9 thru 12	3.12E+01	3.83E-02	9.43E+02	7.97E-04	4.29E-03	1.14E-01	1.04E-05	4.78E+01	3.98E-01	3.50E-03	9.96E+02	1.72E+02	0.00E+00	2.14E-05	7.70E+01	0.00E+00	5.30E-01	0.00E+00	3.44E-02	1.30E+02
13 thru 16	2.78E+01	3.40E-02	8.00E+02	2.88E-04	2.05E-04	8.50E-02	9.19E-06	2.47E+01	7.70E-02	3.11E-03	8.46E+02	1.10E+02	0.00E+00	1.90E-05	1.75E+01	0.00E+00	4.45E-01	0.00E+00	2.04E-02	3.84E+01
17 thru 20	0.00E+00	0.00E+00	1.37E+02	7.80E-03	3.21E-04	1.84E-03	1.09E-09	6.15E+00	1.82E-02	4.34E-04	1.45E+02	1.01E+01	0.00E+00	3.12E-06	7.17E+01	0.00E+00	4.59E-01	0.00E+00	0.00E+00	6.78E+01
21 thru 24, 29 thru 32, and 35 thru 37	4.24E+01	5.21E-02	2.03E+03	6.79E-04	6.05E+01	4.03E-01	2.75E-05	4.36E+02	4.21E+01	5.72E-03	2.16E+03	8.80E+02	0.00E+00	3.11E-05	7.29E+02	0.00E+00	8.87E-01	0.00E+00	2.45E-02	5.86E+03
25 thru 28, and 44 thru 47	0.00E+00	0.00E+00	8.25E+02	3.34E-02	3.84E+02	1.39E-02	4.64E-09	1.70E+02	7.95E+00	1.85E-03	8.72E+02	1.35E+02	0.00E+00	1.33E-05	4.19E+02	0.00E+00	1.96E+00	0.00E+00	0.00E+00	1.12E+04
33 and 34	4.27E+01	5.87E-02	1.56E+03	0.00E+00	3.57E+02	2.60E-02	8.84E-09	2.89E+02	1.12E+01	3.57E-03	1.64E+03	2.43E+02	0.00E+00	2.57E-06	1.11E+01	0.00E+00	4.35E-01	0.00E+00	2.11E-02	1.68E+04
38 thru 43	1.72E+01	2.13E-02	1.06E+03	5.85E-04	2.45E+02	2.37E-01	1.38E-05	3.22E+02	4.27E+01	2.59E-03	1.12E+03	5.98E+02	0.00E+00	1.36E-05	3.23E+02	0.00E+00	4.02E-01	0.00E+00	9.70E-03	5.55E+03
48 thru 51	6.42E-02	7.84E-05	7.94E+00	2.06E-04	5.05E-04	9.67E-04	8.59E-08	7.10E-01	1.97E-02	2.39E-05	8.40E+00	2.04E+00	0.00E+00	1.48E-07	2.26E+00	0.00E+00	1.37E-02	0.00E+00	1.50E-04	5.83E+00

Tank Group	Pr-144 (Ci)	Pu-238 (Ci)	Pu-239 (Ci)	Pu-240 (Ci)	Pu-241 (Ci)	Pu-242 (Ci)	Rh-106 (Ci)	Ru-106 (Ci)	Sb-125 (Ci)	Se-79 (Ci)	Sn-126 (Ci)	Sr-90 (Ci)	Tc-99 (Ci)	Th-232 (Ci)	U-232 (Ci)	U-233 (Ci)	U-234 (Ci)	U-235 (Ci)	U-236 (Ci)	U-238 (Ci)	Y-90 (Ci)
1 thru 8	1.60E-02	0.00E+00	8.10E+00	1.93E+00	5.81E+00	1.15E-03	1.46E-01	1.46E-01	3.71E+01	7.23E-01	1.35E+00	3.46E+04	1.25E+01	0.00E+00	6.22E-04	0.00E+00	0.00E+00	8.60E-04	0.00E+00	3.04E-02	3.46E+04
9 thru 12	4.29E-03	2.02E+02	4.30E+00	1.99E+00	3.90E+01	3.07E-03	8.02E-03	8.02E-03	4.85E+00	3.09E-01	4.12E-01	1.67E+04	5.29E+00	8.70E-04	1.10E-04	2.60E-02	3.80E-03	2.29E-04	4.17E-04	4.42E-03	1.67E+04
13 thru 16	2.05E-04	5.08E+01	2.78E+00	1.07E+00	4.79E+00	5.10E-04	4.76E-04	4.76E-04	1.61E+00	2.75E-01	3.88E-01	1.40E+04	4.70E+00	1.12E-03	1.65E-05	3.01E-02	5.49E-03	1.91E-04	5.22E-04	2.51E-03	1.40E+04
17 thru 20	3.21E-04	0.00E+00	3.01E+01	7.51E+00	4.26E+02	1.16E-02	5.51E-03	5.53E-03	4.00E+00	3.79E-02	7.06E-02	2.10E+03	6.58E-01	0.00E+00	1.17E-04	0.00E+00	0.00E+00	7.88E-04	0.00E+00	5.07E-02	2.10E+03
21 thru 24, 29 thru 32, and 35 thru 37	6.05E+01	1.82E+03	1.66E+01	1.19E+01	8.37E+02	2.59E-02	2.36E+01	2.36E+01	1.90E+02	5.10E-01	5.16E-01	3.92E+04	6.65E+00	2.12E-04	4.25E-05	5.80E-02	2.57E-02	4.94E-04	5.43E-03	2.13E-03	3.92E+04
25 thru 28, and 44 thru 47	3.84E+02	0.00E+00	1.36E+02	3.09E+01	6.83E+02	6.36E-03	3.05E+02	3.05E+02	5.74E+02	1.62E-01	3.01E-01	1.29E+04	2.81E+00	0.00E+00	5.82E-04	0.00E+00	0.00E+00	1.23E-03	0.00E+00	1.13E-01	1.29E+04
33 and 34	3.57E+02	0.00E+00	3.62E+00	8.06E-01	1.70E+01	1.67E-05	3.15E+02	3.15E+02	8.72E+02	3.12E-01	5.80E-01	2.43E+04	5.39E+00	0.00E+00	3.22E-04	0.00E+00	0.00E+00	3.24E-04	0.00E+00	2.63E-02	2.43E+04
38 thru 43	2.45E+02	7.22E+02	7.95E+00	4.97E+00	4.14E+02	1.16E-02	4.63E+01	4.63E+01	1.76E+02	2.31E-01	2.13E-01	2.08E+04	3.92E+00	2.62E-04	4.55E-06	4.96E-03	1.60E-02	2.64E-04	3.60E-03	1.74E-03	2.08E+04
48 thru 51	5.05E-04	1.16E+00	7.14E-01	1.82E-01	1.07E+00	2.12E-04	1.04E-03	1.04E-03	2.37E-01	2.11E-03	2.89E-03	1.41E+02	3.62E-02	5.55E-09	3.06E-06	3.86E-04	2.45E-04	2.64E-05	4.71E-05	1.16E-03	1.41E+02